HEARST WOOD WASTES ENERGY STUDY

A Preliminary Feasibility Study

December 1976

Town of Hearst
and
Hearst Lumbermen's
Association

Ontario

Ministry
of
Energy

Ministry
of the
Environment

HEARST WOOD WASTES

ENERGY STUDY

Co-sponsored by:

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In this edition, mill data has been aggregated to retain confidentiality of individual mill operations and references to potential complex sites have been generalized to avoid land speculation.

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Other EMP reports also for sale at
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Wind Power Report - November, 1975

District Heating Study - February, 1976

Waste Oil Recycling Study - March, 1976

Resource Recovery:
- Energy Analysis of Resource Recovery - April, 1976

Resource Recovery:
- Solid Waste for Industrial Fuel - May, 1976

HEARST WOOD WASTES/ENERGY STUDY

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HEARST WOOD WASTES/ENERGY STUDY

ABSTRACT

The forest products industry in the Hearst area is currently tackling the problems of disposing of wood residues in an environmentally acceptable manner. In addition, energy prices are rising dramatically and the industry faces a possible restriction in energy supply in the near future. Concerned by these problems, a study was commissioned to investigate the technical and economic feasibility of using the wood wastes, augmented by the municipal refuse in the Hearst area, as an energy source.

The wood waste generated by six sawmills and a plywood plant located mainly within a 30-mile radius of Hearst was estimated to reach 179,000 oven-dried tons in 1976. Municipal refuse was estimated at 5,000 tons per annum.

Presently, natural gas and electricity are the two main forms of energy used in the Hearst area. From reported monthly natural gas consumptions of industrial users and annual natural gas and fuel oil consumptions of institutional buildings in Hearst, a list of potential users of thermal energy was established.

Several alternative options for generating thermal and electrical energy, including low pressure steam generation, medium pressure steam and electricity generation, electricity generation and gasification, were evaluated as alternatives to acceptable disposal with no energy generation. Both the economic and technical evaluations indicated the optimum option to be that of steam and electricity generation.

Steam would be supplied as heat energy to three local industries and several institutional buildings, replacing the existing forms of energy in use. The electricity would be distributed by the Hearst Public Utilities Commission. Any excess electricity in non-peak periods would be available for sale to Ontario Hydro, for use by new industries such as greenhouses and/or for use by existing industries near Hearst.

The energy facility was designed to produce 275,000 lb/hr of steam which would be passed through a 12MW turboalternator. A conventional boiler was chosen for steam production and a potential plant site was identified.

A return of 4% to 6% based on 1980 energy prices (expressed in 1976 dollars) would be expected with energy sales of 65,000 MWH of electricity at 17.5 mils and the steam equivalent of 700,000 MCF of natural gas at $1.80/MCF. Potential increases in revenue would put the return in the 8% to 10% range.

It is recommended that the facility should be owned locally.

This study has proved that use of the wood and municipal wastes in the Hearst area for energy generation is both economically and technically feasible. However, a number of commitments are required from the waste suppliers, Ontario Hydro and the potential energy users before proceeding further with the project. In addition, funding will have to be obtained and ownership arrangements finalized.

The actions required to decide on and proceed with the energy conversion facility are itemized in the report.

1. INTRODUCTION

1.1 The Mandate

Much of the wood waste in the Hearst area is currently disposed of by environmentally unacceptable methods, including burning in natural draft teepee burners which emit smoke and odours. To eliminate the smoke and odour, new forced draft teepee burners that have supplemental fuel are required. While using additional fuel which is becoming scarce in Northern Ontario, little use is made of the heat generated by such combustion of wood waste. Furthermore, there is a danger that the continued rise in prices for natural gas and liquid fuel coupled with possible restrictions on supply may, in turn, restrict the development of the forest products industry.

Concerned by these environmental and energy problems, the town of Hearst, the Hearst Lumbermen's Association, together with the Ontario Ministries of Energy and Environment, commissioned SNC Consultants Limited to study the technical and economic feasibility of utilizing the wood and municipal waste generated in and around Hearst as an energy source.

This document is a summary of the Final Report of the study.

1.2 The Criteria

To select the optimum energy conversion system for more detailed examination, a number of criteria were established at the outset of the study. The technical criteria for selection of the system were that it should:

- use efficiently all the waste wood and refuse quantities available,
- use established technology and readily available equipment,
- achieve a high load factor, representing maximum utilization of the installed equipment and therefore minimum capital cost,
- meet environmental regulations.

The economic criteria require that the system at least meet the minimum rate of return considered acceptable for funding by the Province of Ontario.

A conservative approach has been adopted throughout the study, from the BTU values and moisture contents for the wastes to the estimates of capital and operating costs.

2. ENERGY DEMAND AND WASTE SUPPLY

2.1 Available Waste Quantities

2.1.1 Wood Waste

The locations of the seven forest products industrial complexes that were considered as potential suppliers of wood waste for energy generation are shown in Figure No. 1. These suppliers include:

Facility	Location
Levesque Lumber Hearst Ltd.	Hearst
Levesque Plywood Ltd. (plywood & Particleboard)	Hearst
United Saw Mill Co.	Hearst
Lecours Lumber Co.	Calstock
Gosselin Lumber Co. Ltd.	Calstock
Newaygo Timber Co. Ltd.	Mead
Haavalshrud Lumber	Hornepayne

Based on data obtained from the Timmins District Office of the Ministry of the Environment concerning type and quantity of wood processed at the above complexes, and on industry experience of quantities of wood waste produced in sawmills and plywood and particleboard complexes; a total of 179,000 oven-dried tons per year (ODT/Yr) of wood waste was estimated for the year 1976.

The breakdowns of quantities according to mills, wood species and waste type are shown in Table 2.1.

The above quantities include only 40% of the waste from Newaygo Timber Co. Ltd., which presently operates its own energy generation facility, consuming the remaining 60% of its waste.

The solid wood fraction includes planer ends, trims, butt ends, limbs and branches reaching the industrial complexes. The miscellaneous category includes sweepings, shavings and sander dust.

The effect of seasonal variations on quantities of wood waste generated was judged to be insigificant for the purposes of this study.

Other than the current planned expansions, the Hearst Lumbermen's Association has reported no anticipated significant growth in the industry over the next five years. Total wood waste quantities were estimated to be as follows:

	ODT/Yr
1976	179,000
1977	186,000
1978	189,000
1979	192,000
1980	195,000

Each industrial complex presently disposes of its surplus wood waste as follows:

	Disposal Practice
Levesque Lumber Hearst Ltd.	Landfill
United Saw Mill Co.	Teepee burner (new and environmentally acceptable)
Lecours Lumber Co.	Teepee burner (1963) - (no air pollution controls)
Gosselin Lumber Co. Ltd.	Landfill
Newaygo Timber Co. Ltd	Bark to steam generation facility. Remainder landfill
Haavalshrud Lumber	2 teepee burners (no air pollution controls)
Levesque Plywood Ltd. (Particleboard Plant) (Plywood Plant)	Teepee burner (no air pollution controls)

As wood chips are sold to the paper industry by the mills, they have not been included in the wood waste estimated. As least three of the industrial complexes (Levesque Lumber, Lecours Lumber and United Saw Mill) sell sawdust to Domtar in Red Rock, Ontario. However, the quantity sold in any given year is unpredictable as Domtar will not always agree to buy all the available sawdust. Approximately 34,000 ODT of sawdust were sold by the mills in 1974.

TABLE 2.1

WOOD WASTE AVAILABLE

Oven Dried Tons (Estimated for 1976)

A. Quantities Per Mill

Zone	Mill	Waste (ODT/Yr)*
Hearst	Levesque Lumber United Saw Mill Levesque Plywood	
	SUB-TOTAL	107,500
Hearst District	Lecours Lumber Gosselin Lumber Newaygo Timber Haavalshrud	
	SUB-TOTAL	71,500
	TOTAL	179,000

B. Species Breakdown

Spruce		133,000
Jackpine		37,000
Poplar		9,000
	TOTAL	179,000

C. Source Breakdown

Bark		72,000
Sawdust		50,000
Solid Wood		40,000
Miscellaneous		17,000
	TOTAL	179,000

* ODT = Oven Dried Tons

Alternative uses for the wood residue, other than energy generation may become viable in the future. To allow for this eventuality, it was decided to use as a design criterion for the energy facility less than 80% of the presently available waste. Hence a design figure of 138,000 ODT/Yr was established.

Since the quantities and availability of slash in and around Hearst were unknown, and there is some controversy about the desirability of removing it from the forests, slash was not included in the estimates of available residue. Other potential sources of residue include sawmills in the area operating on a sporadic basis, e.g., sawmill at Mattice. Hence the estimated wood waste quantities must be considered to be conservatively low, and an energy facility should have no trouble obtaining 138,000 ODT/Yr.

The Btu values reported in the literature for bark, sawdust and solid vary considerably with the species of wood. A reasonable average for soft wood bark was taken as 8,700 BTU/lb of bone dry solids. A value of 8,000 BTU/lb of bone dry solids was assumed for sawdust and 9,000 BTU/lb of solid wood. Taking the quantities of wood waste in each category and multiplying by the appropriate BTU value results in an average of 8,700 BTU/lb.

To be conservative, a value of 8,000 BTU/lb was used for this study.

The moisture content of the wood waste depends upon the degree and type of processing it has undergone before becoming part of the waste fraction. For example, sawdust from planing operations would obviously be much drier than bark from a wet debarking operation. Based on the literature and practical experience, a conservative value of 50% was assumed for the average moisture content.

If the properties of the wood wastes delivered to the plant show an improvement on these figures, the quantity burned to generate a given energy will be reduced, representing potentially greater energy output from the plant and possibly a saving in haulage costs. The effect of this on operating costs is considered in Section 4.4.

2.1.2 Municipal Refuse

About 10 tons/day of municipal refuse is picked up under contract to the town of Hearst. The municipal service includes households, some stores and service stations but not the larger industries. The refuse is currently disposed of in a site located about 1½ miles from the centre of Hearst. About an equal amount of refuse (10 tons/day) other than wood is estimated to come from the larger industries, such as the sawmills and plywood plant and from residents living outside the town limits. It is difficult to operate the present landfill site in an environmentally acceptable manner and the life of the present operation can only be extended by using land which is potentially unacceptable for this purpose from the environmental point of view.

For the purpose of this study, an average of 5,000 BTU/lb of refuse with a moisture content of 40% was assumed.

2.1.3 Waste Oil

The quantities of waste oil that could be identified amounted to less than 1% of the total available waste. Hence it was considered premature to evaluate in detail the effect of including waste oils on the conceptual design of an energy facility.

2.2 Energy Demand and Consumption

2.2.1 Present Energy Use and Distribution

Data on energy demand and consumption have been obtained for those users in the Hearst area who could effectively be served by a central energy conversion plant.

Natural gas and electricity are the two forms of energy presently supplied to those users. The natural gas can be replaced by a number of alternatives, including steam, circulating hot water, electricity or synthetic gas. There is no suitable replacement for the bulk of the electrical energy used.

Any replacement for natural gas by the above alternatives other than electricity would require a new distribution system which restricts the distance over which it can be economically transmitted. It also would entail energy conversion equipment which imposes a lower limit on the quantity which each consumer can economically use, due to the capital cost of the conversion equipment.

Electricity is presently distributed within Hearst by the Hearst Public Utilities Commission (P.U.C.) which is owned by the Municipality of Hearst. The P.U.C. buys electricity at a wholesale rate from Ontario Hydro. Ontario Hydro distributes electricity directly to residential and industrial users lying outside of the boundaries of Hearst.

Natural gas is distributed directly to the users by Northern and Central Gas, which obtains its gas from TransCanada Pipelines. The main pipeline across Canada runs close to Hearst.

2.2.2 Potential Energy Users

In order to establish the potential market for thermal energy, the reported monthly natural gas consumptions of the industrial users, together with the annual consumption of natural gas and fuel oil of the institutional buildings were analyzed. From these figures, peak demand was projected.

The selected potential users of heat energy include Levesque Plywood Ltd., United Saw Mill, Levesque Lumber Ltd., and institutional buildings as in Table 2.2. The relative locations are shown in Figure 2.

For electrical energy, we have used the premise that the distribution should be related, as far as possible, to the contribution of fuel, ie., wood waste and refuse. This, combined with geographical considerations, has identified Hearst P.U.C. as the primary purchaser, since Levesque Plywood, United Saw Mill and the institutions are included in this system.

It is probable that areas in the vicinity of Hearst, which could include Levesque Lumber, will be annexed by the town of Hearst and could therefore

become customers of the P.U.C., in the fairly near future. Also the possibility of passing on any tariff concessions to waste contributors, (eg., Lecours Lumber and Gosselin Lumber) should be investigated should the energy facility be built.

2.2.3 Demand and Consumption Forecasts

The total annual natural gas (and equivalent fuel oil) consumption for the users tabulated in Table 2.2 was approximately 614,000 MCF in the 1973-1975 period. From these consumptions and the monthly variations (where available), the sum of hourly peak loads was calculated at 344 MCF/hr. This arithmetical total should be reduced by a diversification factor to reflect the different nature of the various potential users and consequent phase difference in peak schedules. We have taken the diversification facter as 0.8. Thus, the system peak load would be 275 MCF/hr. Translating this into a natural gas equivalent steam requirement gives approximately 220,000 lbs/hr, allowing for the thermal efficiency of gas burning equipment. The 220,000 lbs/hr forms the basis for sizing the thermal energy conversion facility.

Allowing for a moderate growth between now and project completion in 1980, we have used a thermal energy consumption of 700,000 MCF/Yr. This figure is the basis of the economic analysis.

The energy demands and consumption of the potential industrial and institutional clients are as follows:

TABLE 2.2

USERS TO BE SERVED WITH STEAM/SYNTHESIZED GAS

	Annual Energy Consumption		Hourly Peak Energy Demand	
	As Gas MCF x 10^3	As Steam Btu x 10^9	As Gas MCF	As Steam Btu x 10^6
Total Industrial	358.2*	287	210	167.6
Total Institutional (20)	72,173	57,807	25,638	20,514

* Incorrect usage found and corrected after final report was issued. Correct usage is 358.2.

The criteria for selection of potential institutional users were:

- use of fossil fuel rather than electricity at present time
- proximity to proposed pipe route from energy facility to United Saw Mill
- magnitude of heating load (related to proximity to proposed pipe route).

The electricity demand level in 1976 is estimated by Ontario Hydro to reach a peak of 10.66 MW and to rise by 1980 to 15.68 MW. Assuming that certain smoothing of peak demand can be implemented and that, failing this, peak power will have to be purchased for short periods from Hydro, a capacity of 12 MW is considered adequate for the proposed plant.

The total annual electrical consumption, at close to 45,000 MWH in 1976, is estimated to increase to 65,000 MWH if Levesque Lumber is included by 1980, and possibly to 75,000 MWH if the area served by the Hearst P.U.C. is widened, or if new industry is developed.

The load duration characteristic of the Hearst P.U.C. system exhibits a sharper peak than for other systems (see Figure 3). Parallel with the development of this project, efforts should be made to improve this characteristic by devising methods of rescheduling and reduction of the peak loads. Possible means for improvement of the characteristic include power factor correction, thermal energy storage and adjustment of industry's operation schedules.

2.3 Estimates of Future Energy Price and Cost

2.3.1 Introduction

In conducting the economic analysis of the energy generation facility, the distinction must be made between the COST of producing energy by alternative means, and the RATES, or price, at which energy is sold.

Assuming, as is the case for Hearst, that there is a significant difference between the wholesale price at which energy is sold and the cost of producing it, the justification for proceeding with a generation facility is stronger if the facility is viable when revenues are set at the lower COST level as well as at the RATE level. This is because rates include the cost of distribution of energy as well as overheads and other indirect costs, and ways of reducing these costs could possibly be found.

It has further been assumed that electricity would be sold to Hearst P.U.C. for distribution.

Costs and rates have been computed in real dollars (1976) in order to avoid taking inflation into account; but these rates have been escalated to represent the real cost in 1980, expressed in 1976 dollars. This is due to the readjustment in energy prices currently taking place.

Based upon current rates and costs obtained from Ontario Hydro, Hearst P.U.C., the Hearst Lumbermen's Association and Northern and Central Gas, and based also upon escalation rates calculated from data supplied by Ontario Hydro, a set of prices has been assumed for this study.

2.3.2 Escalation in Energy Prices

Assuming that escalation in energy costs will be reflected, at least eventually, in rates, the following escalations in real price (excluding inflation) have been assumed:

ESCALATION IN ENERGY PRICES
1976-1980

Basis	Escalation Electricity	Escalation Natural Gas
Current Dollars	76%	115%
Constant Dollars	30%	60%

2.3.3 Costs

The costs of natural gas, of electrical generation in Ontario and of wholesale electricity purchase by Hearst P.U.C. from Ontario Hydro are presented in Table 2.3 (in constant dollars) for 1976 and for 1980, based on the above escalation factors.

2.3.4 Prices

Even when dealing in constant dollars, some uncertainty exists regarding the rise in value of energy over the next few years. This is offset to some degree by anticipated rises in real value over the life of the project, hence making precise estimation for 1980 less critical. However, in order to allow for this uncertainty, a price, based on 90% of the forecast 1980 natural gas and electricity rates, and the 1976 generation costs, was also assumed.

TABLE 2.3

Cost of Energy
(1976 dollars)

	Year	
	1976	1980
Electrical Generation (Province Wide)	12.0 mils	15.0 mils
Natural Gas (wholesale)	$1.20/MCF	$1.92/MCF
(cost in Hearst)	$1.50/MCF	$2.25/MCF
Wholesale Electricity Purchase by Hearst	15.0 mils	19.5 mils

Gas prices were assumed to be somewhat lower in order to allow for the possible lesser convenience of using steam rather than natural gas as a heat energy source. The price levels assumed are presented in Table 2.4.

It should be noted that for ease of comparison, the prices have been concerned with natural gas, when in fact gas will be replaced by steam, or synthetic gas. In computing actual revenue, the conversion to the appropriate quantity of steam or synthetic gas has been made.

TABLE 2.4

Energy Prices 1980
(1976 dollars)

	Price	
	High	Low
Natural Gas (wholesale)	\$1.80/MCF	\$1.45/MCF
(cost in Hearst)	\$2.00/MCF	\$1.80/MCF
Electricity: Generation Cost	15.0 mils	12.0 mils
P.U.C. Wholesale Rate	19.5 mils	17.5 mils

3. PRELIMINARY SCREENING OF ALTERNATIVES

3.1 Alternative Energy Conversion System

Wood waste and municipal refuse can be utilized for energy recovery in a number of environmentally acceptable ways. For the present study the following options, which yield thermal and electrical energy, were considered as alternatives to acceptable disposal with no energy generation:

- low pressure steam generation
- medium pressure steam and electricity generation
- electricity generation
- synthetic gas production

The energy demands met and the thermal efficiency of conversion are both functions of the system chosen. Hence the proportion of waste utilized to generate useful energy is dependent upon the option considered. The percentage of waste used in the energy generation process is indicated in the description of each of the systems below. It should be noted that this percentage is the minimum required to meet the appropriate energy demands. Each system will be capable of disposing of the total quantity of wastes available by condensing excess steam in the case of the steam generation systems or flaring excess gas in the case of the gasification process.

3.1.1 Low Pressure Steam Generation

In this option, waste would be trucked to a central facility, the wood waste hogged and the municipal refuse shredded. The waste fuel would be fired in a conventional steam generator producing low pressure steam for distribution to industry and to the institutional buildings previously identified. The essentials of the system are shown in Figure 4.

Such a system would be sized to generate 250,000 lb/hr of saturated steam at 150 psig to replace the present natural gas demand and consumption of the listed users.

A piping system for distribution of the steam and the return of condensate, together with terminal equipment such as heat exchangers and steam injectors at the users' plants to convert existing heat loads to accept heat in the form of steam, would be integral parts of this installation.

In addition to the waste fuel firing equipment the boiler would be equipped for natural gas firing to permit steam production during periods of non-availability of waste, or breakdown of waste preparation equipment. In the case of breakdown of the boiler or key piping system components, the steam users would resort to their existing heat energy sources which would be retained in working order to provide this stand-by function.

A condenser would be provided to enable excess steam generated from wood waste to be disposed of. This would allow the plant to be used for incineration independently of the energy conversion requirements. Since the flow in the Mattawishkwia River would not be an adequate source of cooling water, we have adopted an air cooled design for the condenser.

This option would use only 55,000 ODT/Yr or 30% of the available waste to replace the 700,000 MCF/Yr of natural gas.

3.1.2 Medium Pressure Steam and Electricity Generation

Waste would be trucked into a central facility as described in 3.1.1, except that the steam generator would produce medium pressure superheated steam. This would be passed through a back-pressure turbine exhausting to the steam distribution system. The essentials of the system are shown in Figure 5.

Such an installation would produce 275,000 lb/hr of steam at 650 psig and 700°F, passing through a 12 MW turbo-alternator feeding electrical power into the Hearst P.U.C. system. Exhaust steam would be distributed to industry and the institutions at 50 psig.

The 12 MW turbo-alternator would meet the present peak load demand of the Hearst P.U.C., and for the majority of the time, excess power could be exported to Ontario Hydro.

As the Hearst P.U.C. system demand increases it would be necessary to import power from Ontario Hydro to cover the peak load periods, but there would still be a net export of power on an annual basis, see Figure 6.

This system would use 138,000 ODT/Yr or 77% of the available waste to generate 60,000 MWH/Yr steam equivalent to 700,000 MCF/Yr of natural gas.

3.1.3 Electricity Generation

A central plant consisting of a high pressure boiler supplying steam to a condensing turbine could be built as shown in Figure 7.

The system would be sized to generate 250,000 lb/hr of steam at approximately 900 psig and 900^{o}F, to drive a 25 MW turbo-alternator. The Hearst P.U.C. load would be met and a considerable excess of electrical power would be available for export to Ontario Hydro. However, as no thermal energy would be produced, the scheme would do little to reduce the natural gas demands of the town, and it would rely very heavily on revenue from sales of power to Ontario Hydro, over which little control could be exercised. The plant size is sufficient to use all the available waste, dependent upon sales to Ontario Hydro.

3.1.4 Gasification Process

Waste would be brought to a central facility and fed to a gasification plant consisting of a number of modules operating in parallel. The low heating value gas (200 Btu/SCF) obtained would be scrubbed and a fraction of it used to incinerate the liquid products of reaction. The remainder would be available for distribution to the industrial users of heat, for fuelling internal combustion engine driven electricity generators and for firing a boiler plant. The system is shown in Figure 8.

In order to explore the full potential of the gasification process relative to the alternatives, two sub-options were examined. The first sub-option considered was a system similar to that described above, but without the electrical energy generation equipment. Since the use of thermal energy is limited by the area which can be served economically by a piping distribution system, and since the wood waste availability would be sufficient to meet the thermal energy needs of this area and provide fuel for the motor generators in addition, we evaluated the feasibility of providing for electrical power generation. We concluded that power generation should form part of the gasification process option, and we have therefore included 4 x 3 MW generators.

Similarly, we evaluated the feasibility of providing a boiler and steam piping system to meet the thermal energy requirements of the institutional buildings and conclude that this should form part of the gasification alternative. This is technically superior to distributing the gas for consumption in individual buildings.

Thus the gasification process would include both engine driven generators and a boiler to serve the institutions. It would meet the projected thermal energy demands and provide fuel for a 12 MW motor generator station feeding power to the Hearst P.U.C., exporting a surplus to Ontario Hydro. This would use 150,000 ODT/Yr or 84% of the available wood waste.

The equipment used in this system is modular, which is not suited to a large central facility, but might be appropriate for smaller decentralized installations.

3.1.5 Acceptable Disposal, No Energy Generation

Wood waste could be disposed of without energy recovery in improved conical incinerators requiring supplemental fuel. Domestic refuse could be disposed of in a properly designed and operated sanitary landfill. These operations would both be more expensive than the current practices of disposal in teepee burners without approved pollution controls and in questionable landfills, respectively. Neither of these disposal methods results in any resource recovery, but both represent a depletion of resources, fossil fuel and land respectively.

3.2 Capital Costs

For the purposes of comparing the above alternatives, capital cost estimates of 20% were developed for each of the four energy generation alternatives as well as the disposal option without energy production.

The capital cost estimates include:

- land
- mechanical equipment
- piping
- electrical power and lighting
- instrumentation and controls
- civil works, i.e., excavation backfill, concrete, structural steel, buildings, roads and fences
- installation and field erection

- contingency
- project management services

Specifically excluded from the estimate are:

- escalation
- royalties, taxes and duty
- bulk haul vehicles for waste fuel and ash
- overtime
- building permits
- owners' costs
- any abnormal items which could not be anticipated from our present knowledge of the area and conditions (eg., need for piling or excessive excavation of rock have not been included).

Major pieces of mechanical equipment were priced by obtaining budget quotations from manufacturers. A list of items for which quotations were obtained forms Table 3.1. Many other smaller items are based on verbal quotations from suppliers.

TABLE 3.1

EQUIPMENT QUOTED BY MANUFACTURERS

Boilers	Babcock and Wilcox Canada Ltd. Foster Wheeler Limited
Fluid Bed Combustion	Copeland Systems Inc. York Shipley Dorr-Oliver Long Ltd.
Turbo Generators	Westinghouse Canada Ltd.
Bark Hogs	Williams Patent Crusher and Pulverizer Company
Bark Storage Bins	S. W. Hooper and Co. Ltd.
Refuse Shredder	Shred-pax
Condenser	Muirhead Engineering

Gasification process - Information was received from Moore Processes

Civil, electrical and mechanical installation, together with bulk material costs were estimated on the basis of in-house data.

The capital costs which were derived are shown in Tables 3.2 a-d.

3.3 Operating Cost Estimates

3.3.1 Fixed Annual Costs

Under fixed annual costs are included those costs that do not vary directly with the quantity of wood wastes consumed, and hence with the energy produced. Included here are the following:

- salaries and wages of personnel
- replacement parts
- auxiliary gas, or oil, for burner start-up, and for emergency steam production
- electricity regularly used in the operation of the plant
- stand-by fixed charges from Ontario Hydro
- stand-by usage charges from Ontario Hydro
- miscellaneous

TABLE 3.2 a

TYPICAL SYSTEM COSTS AND REVENUES

OPTION 1 STEAM ONLY
(Sell equivalent of 635,000 MCF) natural gas)
(Wood waste used: 55,000 ODT/Yr = 30% of available quantity)

CAPITAL COST: $12,400,000

	(x $1,000) HIGH**	LOW**
ANNUAL COSTS:		
CAPITAL: 5% - 20 years	1,045	1,045
OPERATING: FIXED		
Parts	100	100
Labour	300	200
Aux. gas	200	50
Electricity	30	30
	630	380
OPERATING: VARIABLE		
Waste Purch.	0	
Transport: Hearst	75	
Transport: District	0	
Ash Disposal	13	
	88	88
TOTAL ANNUAL COST	1,763	1,513
REVENUE*		
Steam Sales ($2/MCF Gas)	1,270	1,270
NET REVENUE	- 493	- 243
DISPOSAL CHARGE/TON	$9.86	$4.86

* Cost based

** HIGH and LOW costs for labour are discussed in 4.1 and for auxiliary gas in 3.3.1(c)

TABLE 3.2 b

TYPICAL SYSTEM COSTS AND REVENUES

OPTION 2 — STEAM + ELECTRICITY
(Steam: Gas Equiv. 700,000 MCF/Yr)
(Electricity: 65,000 MWH)
(Wood Waste Used: 138,000 ODT/Yr = 77% of available quantity)

CAPITAL COST: $15,200,000

ANNUAL COSTS:	(x $1,000) HIGH**	LOW**
CAPITAL: 5% - 20 years	1,280	1,280
OPERATING: FIXED		
Parts	150	150
Labour	460	250
Aux. gas	200	50
Electricity	45	45
Hydro Standby	135	135
Hydro usage	50	30
	1,040	660
OPERATING: VARIABLE		
Waste Purch.	---	
Transport: Hearst	161	
Transport: District	83	
Ash Disposal	35	
	279	279
TOTAL ANNUAL COST	2,599	2,219
REVENUE*		
Electricity Sales (15 mils)	975	
Steam Sales $2/MCF Gas	1,270	
TOTAL	2,245	2,245
NET REVENUE	-354	26
DISPOSAL CHARGE/TON	$2.60	(-$0.20)

* Cost based

** HIGH and LOW costs for labour are discussed in 4.1 and for Hydro usage in 3.3.1(f)

TABLE 3.2 c

TYPICAL SYSTEM COSTS AND REVENUES

OPTION 3 ELECTRICITY: 210,000 MWH

WOOD WASTE: 162,000 ODT/Yr = 90% of available quantity

CAPITAL COST:	$20,000,000	
ANNUAL COSTS:	(x $1,000)	
	HIGH**	LOW**
CAPITAL: 5% - 20 years	1,685	1,685
OPERATING: FIXED		
Parts	200	200
Labour	460	250
Aux. Gas	200	50
Electricity	60	60
Hydro: Standby - fixed	135	135
usage	50	30
	1,105	725
OPERATING: VARIABLE		
Waste Purch.	---	
Transport: Hearst	161	
Transport: District	164	
Ash Disposal	42	
	367	367
TOTAL ANNUAL COST	3,157	2,777
ANNUAL REVENUE*		
Electricity Sales (15 mils)	3,150	3,150
NET REVENUE	-7	373
DISPOSAL CHARGE	$0.04/ton	---
WASTE PURCHASE	---	$2.30/ton

* Cost based

** HIGH and LOW costs for labour are discussed in 4.1 and for Hydro usage in 3.3.1(f)

TABLE 3.2 d

TYPICAL SYSTEM COSTS AND REVENUES

OPTION 4 GASIFICATION
(Electricity: 89,000 MWH)
(Gas + Steam Equiv.: 700,000 MCF Natural Gas)
(Waste used: 179,000 ODT/Yr = 100% of available quantity)

CAPITAL COST: $22,150,000

ANNUAL COSTS:	(x $1,000) HIGH**	LOW**
CAPITAL: 5% - 20 years	1,867	1,867
OPERATING: FIXED		
Parts	410	250
Labour	475	265
Aux. Gas	1	1
Electricity	60	60
Hydro: standby - fixed	30	30
usage	10	10
	986	616
OPERATING: VARIABLE		
Waste Purch.	---	
Transport: Hearst	161	
Transport: District	215	
Ash Disposal	51	
	427	427
TOTAL COSTS	3,288	2,910
REVENUE*:		
Gas $2/MCF	977	
Steam $2/MCF Gas	184	
Electricity (15 mils)	1,335	
	2,496	2,496
NET REVENUE	-792	-414
DISPOSAL CHARGE/TON	$4.42	$2.31

* Cost based

** HIGH and LOW costs for labour are discussed in 4.1 and for Hydro usage in 3.3.1(f)

The derivation of costs used for each of these categories is discussed below.

a) Salaries and wages of personnel

For each option we developed a station staff, categorized as administrative, operations and maintenance personnel and assigned salaries to arrive at a total annual salary budget. The table developed for the steam and electricity option is shown in Section (Table 4.1).

b) Replacement parts

A percentage of the original equipment cost was used to determine the annual expenditure on spare parts. The percentage used is a function of the type and expected life of the equipment.

c) Auxiliary gas

A percentage of the total annual heat input to the system was used as the basis for the supplemental fuel requirements (this item does not apply to the gasification option since the plant will consist of multiple gas producing units and thereby provide its own back-up). For the boiler options a percentage range has been shown with a minimum of 1¼% and a maximum of 5%. The minimum could be achieved by careful planning of outages and operation without recourse to gas except under the most dire circumstances. It is felt that the maximum figure is comfortably adequate for all normal contingencies.

d) Electricity used in the operation of the plant

An estimate of the electricity consumption of the auxiliary mechanical equipment was made and the annual cost calculated. This is a valid cost since it represents a reduction in the potential revenue from the gross electrical energy generated in the electricity generation options, and an actual purchase of electrical energy in the steam only option.

TABLE 4.1

ANNUAL SALARIES FOR ENERGY CONVERSION FACILITY

	HIGH			LOW		
	No.	Unit Salary $	Total Salary $	No.	Unit Salary $	Total Salary $
Administrative Manager	1	24,000	24,000	-	-	-
- Clerical & Secretarial	4	10,000	40,000	2	10,000	20,000
Operations						
- Operating Supervisor	1	20,000	20,000	1	20,000	20,000
- Stationary Engineers	4	15,000	60,000	4	15,000	60,000
- Ass't Operators	8	12,000	96,000	4	12,000	48,000
- Labourers	8	10,000	80,000	4	10,000	40,000
Maintenance						
- Maintenance Supervisor	1	18,000	18,000	-	-	-
- Tradesmen	10	12,000	120,000	5	12,000	60,000
	37		458,000	20		248,000
			460,000			250,000

Notes: 1. "High" is original estimate for a new facility of this type and size.

2. "Low" is reduced figure to account for those present employees of Hearst P.U.C. who would be absorbed into the new plant.

e) Stand-by fixed charges from Ontario Hydro
As we have
As we have relied on Ontario Hydro for backup facilities, the stand-by rate structure was examined and used to determine the stand-by fixed charge, based on the generator size.

f) Stand-by variable charges from Ontario Hydro

We have estimated the time required annually for maintenance of the generator and other key equipment and allowed for purchase of energy from Ontario Hydro during this period to meet the demand normally met by the plant. This is a valid cost since we have accounted for the entire output of the plant in our calculation of revenue. The minimum charge assumed reflects the more likely level of stand-by energy required from Ontario Hydro.

3.3.2 Variable Costs

Costs related directly to the quantity of wood residue used, are classed as variable. These costs relate to:

- Transportation of wood residue
- Purchase of wood residue
- Disposal of ash

The derivation of unit costs associated with these items is discussed below.

a) Purchase of Wood Residue

Interviews in Hearst indicated that some wood waste, particularly some sawdust, is sold to pulp and paper mills. The point has thus been raised that the possibility of the wood waste having alternative value should be taken into account.

Environment Canada's report "Combustion Technology for Disposal and Utilization of Wood Waste Residue, Economic and Techincal Review", 1975, indicates that while alternative uses, other than in the paper industry, do exist, they currently have relatively restricted markets, although this situation might change.

The current price of sawdust is about $5.50/ton at the mill, and very much higher ($19.50) at the point of delivery, on account of transport costs. However, sawdust is not sold on a regular basis and the price fluctuates. It has been estimated that up to 50% of the available sawdust is sold when market conditions are favourable. It should be noted in this respect that sawdust represents about 25% of the available waste or some 45,000 tons, and hence the potential revenue on half of this would be $123,750 at a unit price of $5.50/ton. If this were the only product with a commercial value, this revenue would be equivalent to $0.70/ton of the combined wood wastes.

For purposes of this analysis it has been assumed that the waste is picked up at the mills free of charge. In practice, if the mills were to deliver the waste to the plant, a payment would be made equivalent to the assumed average cost. Hence, if costs are less than predicted, a portion of profit would be realized on sale of waste.

However, a value might ultimately be assigned to the wood residue (F.O.B. energy generation facility) and this value would increase with inflation.

b) Transportation of Wood Wastes

Transportation cost data were obtained from the Hearst Lumbermen's Association, and from Quirion Transport as well as from general sources. Based on an analysis of this data it would appear reasonable to assume that a truck with a capacity of 35 to 40 tons, would cost between $25 to $40 per hour, for a probable $30 per hour. Using these figures, and probable round trip times between the various mills and the probable plant site, the

following costs have been assumed:

Within the town of Hearst	\$1.50/ODT
Hearst District (average 25 miles)	\$3.00/ODT

These cost levels agree with the estimated from the above sources. Additional data were obtained, in the form of a quote, from Quirion Transport, for haulage from Hornepayne and other distant areas. These costs, of the order of 1.5¢ to 2.5¢/ton mile, were based on economies resulting from Quirion's present haulage contract for chips, and therefore it has been assumed that the cost of transportation from Hornepayne would be based on back-haul following a chip or sawdust delivery, and would be \$3.00/ton.

It should be noted that the costs and operating parameters assumed are conservative, and that actual costs might well be lower for transport in Hearst and district.

c) Ash Disposal Costs

It has been assumed that ash from the furnace will be disposed of by landfill, and that this landfill will require the same stringent conditions as disposal of municipal refuse as discussed in Section 3.1.5. Thus a cost of \$8.50/ton has been derived, assuming suitable land can be found within the boundaries of Hearst, as follows:

Transport	\$1.50/ton
Landfill	\$7.00/ton
Total	\$8.50/ton

Two possibilities exist for reducing the disposal cost, the first being that landfill costs will not be so high and the second that some portion of the ash could be sold for fertilizer or other such use. Assuming a more simplified landfill requirement for the ash, a cost for this aspect of disposal could be reduced perhaps to the order of \$3.00/ton.

3.4 Disposal Charges

Although the wood residues may ultimately have a value, it must be recognized that these residues represent a nuisance today, and that acceptable means must be found for their disposal.

The consumption of municipal refuse and wood wastes in the energy generation facility will mean that alternative disposal methods will not have to be developed by the mill operators and the municipality.

These disposal methods, it must be noted would have to conform to environmentally acceptable standards, and would thus be more costly than methods currently in use.

It is reasonable, therefore, since the generation plant is providing a disposal service, that the generation plant operators should charge for the disposal. The basis for establishing such a charge is presented in the following paragraphs.

3.4.1 Municipal and Industrial Wastes

Disposal costs are $7.00/ton by acceptable methods. Assumed waste quantities are based on 5 days per week.

Town of Hearst Municipal 10 tons/day or 2,500 tons/year.

Other sources 10 tons/day or 2,500 tons/year.

Therefore, neglecting haulage, costs of acceptable disposal would be

Town of Hearst		$17,500/year
Other Sources		$17,500/year
	Total	$35,000/year

However, on account of the possibility of reducing disposal costs through less stringent methods, and to reflect marginal costs of disposal, a disposal charge of $20,000/year has been assumed, for purposes of this study.

3.4.2 Conventional, Acceptable Wood Waste Disposal

Capital and operating cost estimates for acceptable waste disposal with no energy generation for a disposal capacity of 18 oven-dried tons/hour and assuming only two full time operators are as follows:

Capital Cost	$150,000
Amortized Annual Costs of Capital (at 5%)	$ 20,000/year
Annual Operating Cost	$ 44,000/year
	$ 64,000

The disposal capacity on this basis is approximately 70,000 tons per year, on a non-continuous basis or about $1.00/ton. On a continuous basis costs would reduce to about $0.75/ton. However, using this facility to dispose of only 40,000 to 50,000 tons per year would cost $1.50/ton.

Since transportation of wood waste is estimated to be in the order of $1.50/ton within the town of Hearst, it appears to be advantageous for each industry to have its own disposal facility. The two possible exceptions are Levesque Lumber and Gosselin Lumber whose available wastes might be sufficiently small to justify trucking to another industry's burner.

Thus in summary, disposal costs of wood in an improved conical burner would not exceed $1.50/ODT.

3.5 Economic Analysis of Alternative Systems

3.5.1 Introduction to Criteria

The objective of the economic analysis was to ascertain whether the difference between the revenues and the costs, both operating and capital, was likely to be sufficiently great to justify adoption of any of the options. The analysis was limited to the energy generation plant, treating

it as a independent facility which obtains its raw material inputs from the mills, and sells the energy produced. In the case of electricity, it would sell wholesale to Hearst P.U.C. and possibly to Ontario Hydro, and in the case of steam or gas, it would sell direct to the users.

Discussions in the course of the study indicate that a discount rate of 9.75% to 10.5% is in current use for projects of this nature and that this rate includes provision for inflation.

In view of the uncertainty and lack of accuracy attached to forecasting inflation beyond 1980, the economic analyses have been carried out excluding inflation (in 1976 dollars). However, the order of magnitude of impact of including inflation was investigated and is presented in Section 4. Thus, a lower discount rate can be chosen, and has been assumed at a lower bound level of 4 to 5%. This is supported by data from Ontario Hydro indicating a required real return of 3.5 to 4% and a forecasted inflation rate of 5 to 7% (past 1980). These latter figures indicate that a lower return might be strictly admissible, but this had been judged to be too close to the border-line when allowing for risk. In practice, financial institutions would probably seek a rate of return closer to the 10% level, even net of inflation, prior to financing a project. This is because of the need to provide adequately for risk.

In order to establish the viability of the proposed plant it was decided that utilizing the criterion of Internal Rate of Return of the project would yield the most meaningful basis for comparison.

The Internal Rate of Return in this context is the rate of interest, or discount rate, at which the present value of the future annual net revenues (annual revenues less annual expenses) is exactly equal to the capital cost of the project.

It should also be noted that a range of operating costs has been used. Here again, acceptable rates of return with the pessimistically high costs, indicates a strong project.

A further question is whether the option can meet the foregoing criteria when excess energy is sold to Hydro, and when it is not.

3.5.2 Analysis of Alternative Systems

In order to compute the internal rate of return for each option, use was made of a computer program designed for economic and financial feasibility analysis. This program permits rapid computation of the return as well as of the net present worth at various interest rates, for any option and, in addition, is extremely useful for exploring the sensitivity of the solution to the assumed values of cost and revenues.

Typical cost and revenue breakdowns for each of the alternatives assuming a 5% discount rate and 20 year amortization, are presented in Tables 3.2 a) to 3.2 d). These tables also indicate the price or charge for available wood waste.

The rates of return obtained for all the variations studied assuming a 20 year project life are presented in Table 3.3. The cash flow analysis for a variant of the Steam and Electricity option is presented in the format of the computer program output shown in Table 3.5(a), (Appendix.). Included in this table are the discounted present worths at various discount rates. Note that the present worth of zero lies between 4% and 6%, and would in fact be at 5.3%, which is the internal rate of return.

In Table 3.5(b) (Appendix), the results of introducing the disposal charge of $220,000 is illustrated raising the internal rate of return to nearly 7%. As discussed in Section 5, when inflation is taken into account, returns are in the range of 10% or better.

These economic analyses compute the viability of the options from the provincial point of view. That is, where the economic criteria are met, the project would be justifiable in terms of alternative energy generation options such as large scale thermal plants. The viability from the point of view of Hearst will be greater, since higher rates for sale of electricity can be used.

3.5.3 Selection of Energy Conversion Systems

On the basis of the criteria established for rate of return it can be seen from Table 3.3 that only the "Steam and Electricity" Option (No.2) passes the test when meeting the energy demand for the Hearst area. However, if it were possible to sell surplus electricity to Ontario Hydro, both Options No. 2 and No. 3 "Electricity" would be acceptable.

The alternative of using the all electricity option (No. 3) to provide the electricity requirements of Hearst alone was found to generate insufficient revenue compared to costs and is therefore not presented in the analysis.

The gasification option (No. 4) was found to yield a rate of return of 3-4% if operating costs can be low, but is clearly inferior in comparison to Options 2 and 3.

3.6 Selection of the Most Favourable Option

3.6.1 Evaluation

The degree to which each of the options respects the economic technical and other criteria is indicated in Table 3.4. As can be clearly seen, only the steam and electricity option is economically viable when meeting Hearst's energy needs alone, as well as when selling surplus electricity to Hydro.

Options 3 and 4 both require more than the target of 80% of woodwastes, and in addition, Option 4 "Gasification" cannot yet be considered a proven technology.

All options meet environmental standards, and are reasonably efficient converters of energy. However, the steam and electricity option is more efficient than the steam option, since a greater utilization is made of generation potential. Steam in its turn is more efficient than either the Electricity or Gasification options.

TABLE 3.3

SYSTEM EVALUATION RATES OF RETURN

SYSTEM	REVENUE	RATES OF RETURN - %							
		65,000 MWH 15 mils				85,000 MWH 15 mils			
	COSTS (1)	HIGH		LOW		HIGH		LOW	
	DISP. CHARGE (2)	NO	YES	NO	YES	NO	YES	NO	YES
1. Steam		-1	0	2	-	-	-	-	-
2. Steam and Electricity -	A			1.6	4.1			3.4	5.7
	B	2	4	2.7	4.8	3	5	4.1	6.1
	C			3.5	4.7			4.1	6.1
3. Electricity		-	-	-	-	5	6	7	8
4. Gas and Steam and Electricity		-3	-1	1	2	0	1	3	4

NOTES: (1) Costs HIGH and LOW as on Tables 3.2(a) to (d)
(2) Disposal charge levied on producer
A No steam supplied to institutional buildings or United Sawmills
B Supply steam to institutional buildings and United Sawmills
C Supply steam to institutional buildings but not to United Sawmills

On the basis of the Assessment of the options, as summarized in Table 3.4, Option No. 3 - Steam and Electricity is the preferred choice since it is viable when meeting only the energy requirements of Hearst, and meets all other criteria

3.6.2 Plant Capacity

Characteristics of a waste fuel fired plant are high capital cost and relatively low operating costs, which are fairly constant irrespective of plant load.

This translates into the construction of the smallest possible installation capable of using the fuel available, with the ability to meet system peak demands being of secondary importance. In the present case, however, it will be possible to meet the peak thermal loads of the listed users and the peak (1976) electrical load of Hearst P.U.C. The fact that the peak electrical load in a few years will exceed the capacity of the plant does not detract from the feasibility of the project, since the existing link to Hydro which will enable future peak loads to be met is an essential part of the system, both for the provision of a standby power supply and to permit sales of electrical power in off-peak periods. Figure 3 (Hearst P.U.C. load duration curves for period 76-81) shows that the import of peak electrical power will be greatly exceeded by the export potential for the period covered. Moreover, Ontario Hydro prediction of a 10% annual increase in peak electrical load for Hearst (on which Figure 3 is based) is somewhat higher than the increase we would expect, from our knowledge of projected industrial, institutional and population growth.

TABLE 3.4

GENERAL SYSTEM EVALUATION

CRITERIA	1. STEAM	2. STEAM + ELECTRICITY	3. ELECTRICITY	4. GASIFICATION
Wood Residue 80% used	●	●	-	-
Proven Technology	●	●	●	-
Environmental Acceptability	●	●	●	●
Efficient Energy Conversion	◐	●	○	○

● Good

◐ Moderate

○ Poor

\- Negative

4. DETAILED ANALYSIS OF SELECTED OPTION

4.1 Technical Description of System Selected

The system outlined in 3.1.2 for the conversion of energy in wood waste and refuse to thermal energy and electrical energy is detailed below. Figures 11 through 15 should be referred to in the context of this description (see Appendix). An equipment list will be found in the Appendix.

a) Waste Handling

Waste will be trucked into the plant, weighed on the weigh scale adjacent to the office and thereafter the various categories will be processed separately. Wood waste, other than sawdust, will be unloaded from trucks on to a flight conveyor which will discharge in the centre of the storage yard. It will be distributed in the yard and reclaimed by a bulldozer, which will feed material to the bark hog feed conveyor. The wood waste will be reduced by a single horizontal hog capable of handling 30 T/hr to a nominal 3" size, and conveyed by a pneumatic system to the top of the storage bin, where it will be separated from the air stream by a cyclone. The hog will reject material it is unable to reduce.

The sawdust will be discharged from trucks on to a belt conveyor which will feed a storage bin, physically similar to the "bark" storage bin and located beside it on the mezzanine level above the waste preparation room.

The municipal refuse will be discharged from vehicles into a three-sided concrete pit sized to hold 100 tons (one week capacity). It will be handled by bulldozers on to the refuse shredder feed conveyor A hand-sorting station will be provided to prevent hazardous materials from reaching the shredder. It will also allow for the salvage of materials having resale value. The shredder is sized for 5T/hr and will therefore normally operate 4 hours per day reducing refuse to a size similar to the hogged wood waste. The shredded refuse will be conveyed by a bulk-flo conveyor to the front end of the bark storage bin.

The storage bins are sized to hold a combined total of approximately 225 ODT of waste, or 12 hours supply of fuel. The sawdust bin will hold one day's normal throughput of sawdust, and should, therefore, obviate the need for storage of sawdust outside. When sawdust is available it will be burned in preference to solid wood waste. The bark storage bin alone has a capacity sufficient to permit operation of the plant for 6 hours, so that an outage of this length can be sustained for maintenance of equipment upstream of this, even when no sawdust is available. When sawdust is available, the plant would be able to run at full load for 12 hours on the fuel already processed.

The storage bins discharge by means of live bottoms which move the material to the front, and transverse screw conveyors transfer it to a series of chutes which mix the sawdust with the hogged wood waste and refuse, and feed the burner wind swept spouts.

b) Boiler System

The fuel is burned in the furnace partly in suspension and partly on the ash removal grate. Coarse ash is discharged from the end of the grate to a hopper, which is periodically emptied by a conveyor system to vehicles for trucking to landfill. Fly ash is removed from the system by two stages of mechanical separators, and combined with the coarse ash for trucking out of the plant.

The steam generating unit is a radiant water cooled natural circulation boiler, with convective tube banks of superheater, evaporative and economizer heating surface. Also in the boiler package are forced draft and induced draft fans, tubular air heater, dust collectors, sootblowers, firing equipment for the waste fuels and for natural gas, instruments and controls. The natural gas burners will permit operation of the plant when waste fuel is not available and facilitate start-up, combustion stabilization when firing very wet fuel, and peak load trimming.

The unit will have a capacity of 275,000 lb/hr steam at 650 psig, superheated to 700°F, from feed at 350°F. The steam generated will be passed through a turbo alternator designed to generate 12 MW at 15 KV, and to exhaust steam at 50 psig. The turbo alternator package will include a lubrication system, emergency turning gear, instruments and controls and all other auxiliary equipment.

c) Stack

The flue gas, after passing through the dust collectors will be discharged to the atmosphere by a 150' high 6' dia steel stack. Stack dispersion calculations were carried out to ensure that the stack dimensions chosen will result in compliance with air pollution regulations, i.e., that the ground level concentration (30 min. average) of particulates will not exceed 100 micrograms per cubic meter. The calculated maximum ground level particulate concentration is 25.6 micrograms per cubic meter.

d) Steam Distribution

The low pressure (50 psig) steam distribution piping will serve the industrial and institutional users. It will consist of a system of insulated and cased steam supply and condensate return pipes. The main run of piping will be above ground on an architecturally designed supporting structure. Underground sections will be incorporated to facilitate crossing of the highway and railway. Piping could all be underground but this aspect of the design should be reviewed as the project proceeds.

Suitable equipment will be provided to enable heat to be extracted from the steam. In the industrial context this could take the form of ejectors to heat hot ponds by direct contact, steam to hot water shell and tube heat exchangers and steam coil space heaters. For the institutional buildings, hot water heating systems would be served by shell and tube heat exchanger incorporated into the existing circulation loops, and warm air systems by steam coil heat exchangers located in the existing ductwork. In the case of the hospital, which is steam heated, steam from the distribution system will be passed through the existing heat transfer equipment.

The majority of the condensate will be returned to the central plant for reuse as boiler feed-water. The returned condensate will pass through a polishing plant and supplemented as necessary

by demineralized make-up water. The mixture will pass through the boiler feed train which consists of condensate pumps to deliver the water to the spray type deaerator where dissolved gases will be scrubbed out by the injection of steam at 40 psig. The feed water will leave the deaerator at 280^{o}F, and will pass through the boiler feed pumps to a steam heated feed water preheater where it will be heated to approximately 350^{o}F prior to passing to the boiler.

Provision will be made for bypassing the live steam around the turbine to the 50 psig system. The bypass will be achieved by two stages of pressure reduction, from 650 to 150 psig, and from 150 to 50 psig respectively. The bypass will serve two functions. Firstly, when the turbine is out of service for maintenance or due to breakdown, it will permit the supply of steam to the distribution system to satisfy the heat loads. Secondly, when the turbine is in service it will be possible to bypass a proportion of the steam generated so that heat loads greater than that corresponding to the prevailing electrical load can be met.

e) Condenser

To extend this concept of operational flexibility, an air cooled condenser will be incorporated into the system. This will be sized to condense the full steam output of the boiler after pressure reduction to 50 psig, and will serve three functions. Firstly, it will enable the electrical load to exceed that which corresponds in terms of steam flow to the prevailing heat load. Secondly, it will enable electrical energy generation to proceed when the low pressure steam distribution piping is not available for service, and thirdly, it will permit the incineration of waste fuel in excess of the energy conversion requirements of the system. Condensate from the condenser will be piped into the condensate return line of the distribution and return system.

Thus the bypass and condenser will enable the three energy goals, namely waste fuel, electricity and low pressure steam, to be manipulated independently of each other up to the limit set by waste fuel availability.

f) Waste Oils

The burning of waste oils in a boiler such as the one proposed would pose no technical problems, other than the addition of oil tankage, pumping and heating equipment and an oil burner. The quantities which we understand would be available within a 100-mile radius would amount to only approximately 100,000 gals per year or less than 1% of the heat input to the boiler. Thus it would not appear to necessitate any additional flue gas cleaning equipment or stack height. Its value as a supplemental fuel would be limited both by the small quantity available, which would be inadequate to replace gas as a standby fuel and the additional equipment, which would be required to burn it. However, a more detailed investigation of potential corrosion and air pollution problems, resulting from the contaminants in the waste oil, should be undertaken before incorporating it as a fuel in the energy facility. Our feeling is that there are many potential users of waste oil much closer to the individual sources, and there would be little purpose in transporting waste oil to this facility which can make no better use of it than, say a standard oil fired package boiler.

g) Future Expansion

The future expansion of energy consumption and waste fuel production can only be met in fairly large discrete increments of plant capacity, if the same technical approach is adopted. The size of the turbo generator used in the proposed facility is close to the minimum commercially practical size and, thus, the logical size increment would result in a doubling of plant capacity.

However, it would probably be advantageous to meet expanded wood waste production by installing an energy conversion facility at one of the outlying sources of wood waste and thereby relieve the load on the existing plant. Such a facility would not necessarily be based on the same technological

system but could, for example, take the form of a fluid bed unit or gasification plant provided that, by the time such a future expansion were undertaken, reliability and technical suitability of the selected system were judged to be adequate.

4.1.2 Conventional vs Fluid Bed Technology

The generation of steam can be achieved in two ways. In a conventional boiler, hogged wood waste and shredded refuse are fired partly in suspension, and burn-out is completed on a continuous ash discharge grate. The unit is an integrated radiant water cooled furnace and convection pass in which the flue gases are cooled by tube banks, prior to passing through gas cleaning equipment, as described above in 4.1.1(b).

The alternative approach involves a series of equipment modules. Hogged (or shredded) fuel is fed to a refractory lined combustor containing a fluidized bed of sand in which the fuel burns.

The flue gases are ducted to a waste heat boiler where the heat is extracted in raising steam and from there to gas cleaning equipment to remove particulate matter.

In our review of the two types of steam generator, we obtained pricing information from two conventional boiler makers, and found their prices consistent with each other. However, the three suppliers of fluid bed steam generators were widely divergent both in the scope of equipment offered and in pricing. Prices for fluid bed boilers ranged from considerably below conventional boilers to considerably above, dependent on supplier.

Fluid bed boilers are not available in the capacity which would be required for the energy conversion systems under consideration, which would mean resorting to parallel units. We have only been able to find information on one installation in Canada burning solid wood waste, and this is not a steam raising unit, let alone an electricity generating facility.

Other factors in favour of a conventional boiler are:

- smaller thermal inertia, allowing more rapid load following

- lower power requirement for driving auxiliary equipment.

Our analysis of the factors enumerated above results in the choice of a conventional boiler rather than a fluid bed combustor with waste heat boiler at this time.

4.1.3 Project Schedule

The project schedule for engineering, procurement and construction of the energy conversion facility has been developed.

The elapsed time between the start date and the project completion can be estimated with some precision. The plant item which determines the project duration is the boiler and the critical path of major activities for the boiler is:

Engineering prior to placing boiler order (by project manager/engineer)	4-6 months
Design and fabrication (by boiler supplier)	20-24 months
Field erection (by boiler supplier)	9-12 months
Start-up, testing and putting into commercial operation (by boiler supplier)	1-2 months
	34-44 months

These durations are based on the implementation of a fully co-ordinated project management approach.

Thus, a realistic target, based on the established technology of the steam and electricity alternative, would be 36 months reckoned from the date on which an instruction to proceed could be implemented.

If it were desired to insert the process of developing a definitive estimate into the schedule prior to making the final decision to proceed with the project, an extension of 3-4 months would occur. We therefore feel that the project could be completed and the plant operational during the year 1980, subject to a reasonably early start.

If, however, the project were implemented without full project management services, i.e., if design, procurement and construction were handled as separate phases, a substantial extension to the project duration would occur since these three phases could not be interlocked and scheduled concurrently to the same degree.

4.1.4 Capital and Operating Costs

The capital cost of this plant was determined by refining the estimate described in 3.2 to provide an accuracy of $\pm$ 10-15%. The cost of the project on this basis is $15,200,000, for the scope as defined in 3.2.

For the economic analysis, we have assigned a project life of 20 years, which is considered reasonable since the technical life of the plant in terms of durability of equipment will be in excess of 30 years. However, the economic life could be shortened by the arrival on the scene within this time frame of more attractive uses for wood waste.

Operating cost estimates developed in 3.3 were sufficiently accurate to be used without further refinement.

A tabulation of the payroll costs is shown in Table 4.1. See Page 26.

4.2 Site Selection

Within the constraints of the local geography and proposed technology, the criteria for site selection include:

- proximity to centroid of thermal load to minimize piping runs
- good road access
- adequate area for wood waste storage
- level ground
- conformity with Hearst Town Plan
- availability of property

We examined a number of potential sites.

The importance of proximity to the thermal load centroid is paramount because of the effect on capital cost of variation in piping length. Since the two major thermal energy users are Levesque Plywood and United Saw Mill Company, the locus of optimum sites lies on the axis between the two.

All available sites which meet this first criterion appear to have equally good road access. Site alternatives have been recommended to the Ministry.

4.3 Economic Analysis of Selected System

4.3.1 Motivation

Having determined that, under appropriate conditions, both the "Steam and Electricity" and the "Electricity" options met tests of minimal feasibility from the Provincial viewpoint and that the "Steam and Electricity" option was to be preferred, this option was then analyzed in more detail. The purpose of this analysis was to determine the anticipated rate of return if electrical energy is sold at a price based upon the rate that would be charged by Ontario Hydro, and under various scenarios regarding operating costs, quantity of electricity sold and the presence or not of a disposal charge.

4.3.2 Variation with Sales and Price of Energy

a) The Analysis

The rates of return obtained when the low price level is set at 17.55 mils and $1.80/MCF (Section 2.3) are presented in Table 4.3 for various quantities of electricity sold. Also indicated are the rates of return when selling 65,000 MWH at the full rates of $2.00/MCF and 19.5 mils.

Details of the cash flow analysis and present worths obtained at various discount rates are presented in the Appendix, Table 4.4a for the variant of "Low Costs" and "No disposal charge". Increasing revenue by imposing a disposal charge of $220,000 raises the internal rate of return to 8.07% from the 6.45% obtained with no disposal charge (see Tables 4.4a and b, Appendix).

The results are seen to be sensitive to both the level of operating costs and whether or not a disposal charge is levied. The disposal charge, which increases revenue by upwards of $200,000 per year yields an increased rate of return of from 1.5% to 2.5%. An increase of about 3% results from the difference between high and low operating costs, which is in the order of $375,000 per year. These results are presented graphically in Figure 9 as a function of electricity sales.

b) Conclusions

Given the current electricity demand levels, within Hearst, the 65,000 MWH sales target would appear reasonable if Levesque Lumber and recently annexed sectors of Hearst are included in the Hearst P.U.C. area. The 75,000 MWH target would be attainable towards the end of the project life at current rates, or sooner if an additional use for energy were developed, such as a new industry.

The results presented in Figure 9 indicate a reasonable confidence of attaining a rate of return in order of at least 5% to 8%. The actual return, when inflation is taken into account, will be significantly higher (see Section 4.5).

The payback period, as indicated in Table 4.3 would range from 8 to 14 years depending upon sales, costs and revenue variations.

4.3.3 Wood Waste Purchase Mechanism

In the foregoing analysis, it has been assumed that wood waste purchase, transportation and disposal charges are separate items. The price paid for wood waste has been assumed to be zero.

In practice, a value could be established for wood waste, and if the mills are responsible for delivering waste to the energy facility, the price paid for wood waste would be established "F.O.B. Generation Facility". This price would be determined by the following calculation: (value established for the waste plus transportation cost minus disposal charge levied). If a positive value is established for the wood residues, it would probably vary with types of waste, with sawdust meriting a higher price than bark, for example. For ease of comparison, a uniform average price has been used to investigate the effect of the price paid for wood waste on the rate of return (see Section 4.3.4)

4.3.4 Variation of Rate of Return with Price of Wood Waste

The effect of an "F.O.B. Energy Generation Facility" price for wood waste on the rates of return of the project is shown in Figure 10. The values are expressed in average terms, to account for waste transported from mills both within Hearst and the surrounding district. The cases with and without a disposal charge (HIGH and LOW) are both considered.

4.4 Sensitivity Analysis

As previously mentioned, a conservative approach has been adopted throughout the study. In this section, we investigate the effects of reduced moisture contents and increased Btu values for wood waste, and sales of additional electricity and steam.

TABLE 4.3

Steam and Electricity Option
Detailed Analysis of Rate of Return

ENERGY SOLD	Equivalent Natural Gas (MCF)	RATE OF RETURN					PAYBACK PERIOD (years)	
		Revenue	Medium					
		Costs	High		Low			
		Charge	No	Yes	No	Yes	Max.	Min.
Steam	700,000							
Plus								
65,000 MWH	400,000		3.5	5.0	4.5	6.2	14	9
85,000 MWH	500,000		5.0	7.5	6.0	8.0	12	8
65,000 MWH*	475,000		5.5	7.5	6.5	8.0	--	-

Revenue: Medium, Gas/Steam $ 1.80/MCF
Electricity $ 17.55 mils.

Costs: High: $1,036,000/yr
Low: $ 660,000/yr

Charge: (for disposal) Municipal: $20,000
Industries: $1.50/ton

* Revenue at: Gas/Steam: $2.00/MCF
Electricity: 19.5 mils.

4.4.1 Effect of Moisture Content and Btu Value

An average moisture content of 50% for the wood waste has been assumed, but indications are that 40% might reasonably be expected. This would reduce the number of net tons of wood waste to be handled and would thus reduce transportation costs. The number of oven-dried tons required for com--bustion would also be reduced, due to increased efficiency of energy conversion. Thus, unit costs per ODT would be reduced.

Similarly, an increase in calorific value from 8,000 Btu/lb to 8,500 Btu/lb would result in less waste required for a given energy output.

The effects of these changes in Btu value, moisture content and thus transportation costs are summarized in Table 4.4. It can be seen that an annual savings of $81,520 would be realized by a decrease of moisture in the wood waste to 40% and an increase in calorific value to 8,500 Btu/lb.

4.4.2 Impact of Sales of Additional Energy

a) Price Reduction with Output

As indicated in Table 4.3, the rate of return increased by about 1% for every 10,000 MWH increment in electricity sold. Instead of increasing return on investment, it would be possible, at least technically, to reduce the sales price of electricity to a level which yields the same return on investment. The net revenue accruing from increased production and sales of electricity can be deducted from the revenue obtained from electricity sales, and prorated to determine the effective unit price, as illustrated in Table 4.5.

b) Available Steam

A possible means of increasing total energy demand would revolve around the use of the excess steam available in non-peak periods. This could serve as an incentive to the setting up of industries such as greenhouses, which could use non-peak energy by employing thermal reservoirs.

4.5 Estimated Impact of Inflation

In the following paragraphs, the impact of inflation on cash flow and rates of return is investigated to give its effect on the viability of the project. However, this is not a detailed analysis and does not therefore override or replace the "no inflation" analysis.

Assuming that the capital funds for the project will be required in 1978, and that construction cost escalations as per Ontario Hydro data will be:

1976-1977	10.5%
1977-1978	9.2%

the capital required will be: $18,340,000.

Assuming that 25% of the financing is obtained as grants, the amount to be financed will be:

$13,755,000.

The Ontario Hydro forecasting series indicates that inflation between 1976 and 1980 will be in the order of 9%-10% per year, reducing to 5.5%-7% past 1980. Hence a figure of 6% from 1976 onwards has been applied to all costs and revenue items, except for the disposal charge, which was presumed constant. This implies a gradual phaseout of this charge over time to reflect increased value of waste.

The internal rates of return and cost flow applicable at the Provincial level, (15 mils and 1.80/MCF dollars) with inflation taken into account are in the order of 10%, significantly higher than the "net of inflation" case (see Table 4.6). Hence the viability of the project clearly improves when inflation is taken into account.

TABLE 4.4

Potential Reductions in Annual Cost

MOISTURE CONTENT	BTU VALUE	WASTE REQUIRED ODT/YR	TRANSPORT COST ($1,000) HEARST	DISTRICT	TOTAL
50 Percent	8,000	138,000	161.25	91.5	252.75
40 Percent	8,500	122,240	134.38	36.85	171.23
Difference		15,760	26.87	54.65	81.52

TABLE 4.5

Variation of Electricity Price With Output

SALES OF ELECTRICITY MWH	INCREASE IN NET REVENUE	ELECTRICITY REVENUE (GROSS)	REDUCED ELECTRICITY REVENUE	UNIT COST
	x$1,000	x$1,000	x$1,000	$/MWH
65,000	-	1,141	1,141	17.55
75,000	105	1,319	1,214	16.20
85,000	213	1,496	1,283	15.10

TABLE 4.6

ECONOMIC ANALYSIS
IMPACT OF INFLATION

	NO DISPOSAL CHARGE	DISPOSAL CHARGE
No Inflation	5%	7%
Inflation of 6%	9.5%	10.5%

5. OWNERSHIP AND FINANCING

5.1 Introduction

While ownership and financing are in many instances closely inter-related, it is useful to initially consider them separately.

It is accepted that the generation facility will sell its electricity to the Hearst Public Utilities Commission (P.U.C.) for distribution; but the ownership of the steam distribution facilities is to be determined. Ownership options that could be applicable are:

- Hearst P.U.C.
- Local Industries (Hearst Lumbermen's Association)
- Hearst P.U.C. and Industries
- Third Party (Public or Private).

Ownership will be determined by the need for control. Financing of the facility will depend upon the ownership but would be achieved through a mix of the following alternatives:

- The Owners
- Bank Financing
- Grants
- Provincially Guaranteed Loans

5.2 Ownership

5.2.1 Criteria

Ownership implies control, which in turn protects the equity and the interests of those associated with or affected by the facility. This latter point is of particular importance where public monies are involved. The criteria against which ownership options for the facility should be evaluated include:

- Respect public utility regulations
- Qualify for Tax exempt status
- Guarantee supply of wood residue
- Protect public interest.

a) Public Utility Regulations

The public utility act and regulations apparently permit a Generation Plant to provide electricity to its owners and also permit a Public Utilities Commission such as Hearst P.U.C. to sell electricity within the municipal limits.

Thus, while negotiations would be required with Ontario Hydro in respect of the present long term contract to supply electricity, a major involvement by Hearst P.U.C. would appear to be desirable.

b) Tax Exempt Status

According to information obtained from Revenue Canada, the facility would pay tax at an effective rate of 50% on taxable income unless it qualifed as a "Tax expemt corporation". A tax exempt Corporation is defined by the Tax Act as one which is owned 90% or more by a Canadian Government or Government Agency. This would appear to include the Municipality of Hearst and the Hearst P.U.C. (as per telephone conversation with Revenue Canada).

A further point of note is the existence of the Public Utilities Income Tax Transfer Act, under which 95% of the Federal Tax would be returned to the Provincial Government, in this case, Ontario.

Thus, if ownership were such that income taxes were paid, there would be justification for direct financial aid from the Province equivalent to the Provincial taxes and 95% of the federal taxes. However, it is clearly more simple if the facility were tax exempt.

Ownership by Hearst P.U.C. would also overcome the need for grants in lieu of real estate taxes as would be required of a tax exempt corporation.

c) Guarantee Supply of Wood Residue

Contractual and incentive schemes can be developed to guarantee the supply of wood residue.

d) Protection of Public Interest

It is desirable that no particular category of customer or interest group have undue influence over the operation of the facility, and yet that those who are affected by the operation of the plant have their interests protected.

This indicates that there should be representation of the citizens of Hearst in the control of the facility, and also of the industries and community institutions buying energy. These requirements could be met by ownership involvement by Hearst P.U.C. and the Hearst Lumbermen's Association (H.L.A.) industries. Alternatively, an independent commission or agency could be created with each interest group nominating representatives to the board of directors.

5.2.2 Evaluation

The extent to which the ownership options respect these criteria is indicated in Table 5.1. The option of ownership by the industries of the H.L.A. is clearly unattractive. The advantages of tax exempt status eliminates a greater than 10% involvement by non-governmental agencies.

TABLE 5.1

OWNERSHIP OPTIONS AND CRITERIA

	Hearst PUC 90%	HLA	Third Party (Public)	PUC + HLA
Public Util. Regulations	●	–	●	◐
Public Interest	●	–	◐	●
Tax Exemption	●	–	●	–
Waste Supply	○	●	○	●

● Positive

○ Possible

◐ Dependent upon details of scheme

– Negative

It is also felt that the small scale of the plant points to ownership and control by a local body. The two most attractive options are thus an independent public utility with representation on the Board of Directors by Hearst, the P.U.C. and the industries, or alternatively ownership by the Hearst P.U.C. with possible minority holdings by the principal beneficiaries, namely the industries.

Once the desirability of proceeding with the energy conversion facility is accepted, it will be necessary to obtain financing under terms that will enable the facility to be operated on a sound financial basis. Thus the financing method chosen should be such that the debt repayment allows a reasonable operating margin, and yet requires that the facility be efficiently operated if this margin is to be achieved. Comment was made on financing options which included grants and loans.

Grants and guaranteed loans are required in order to ensure that the plant and related distribution system can operate on a sound financial footing. The actual proportions will depend upon a detailed study of available grants, the approval for these grants, and upon the results of negotiations between the parties involved.

6. CONCLUSIONS OF THE STUDY

This study has shown that it is both technically and economically feasible to build a central energy generation facility in Hearst using wood and municipal residues as fuel.

To balance the energy demand and available waste, the facility has been designed to produce 275,000 lb/hr of steam which would be passed through a 12 MW turboalternator feeding electrical power into the Hearst P.U.C. system. Several potential industrial and institutional clients have been identified for the exhaust steam. The electricity would be used by the Hearst P.U.C. with excess electricity being sold to Ontario Hydro. In peak load periods, electricity would have to be obtained from Ontario Hydro, as the system demand increases.

The generation of Steam and Electricity to meet the demands of Hearst (65,000 MWH), has a rate of return just adequate when priced at a level of 15 mils, which is equivalent to the cost of producing energy by alternative means. This would justify support by the Provincial government. It is reasonable to expect that the cost of electricity to Hearst P.U.C. would be at least two to four mils greater than this, and hence a higher rate of return is to be expected. A return of 5% to 8% based on 1980 energy prices (expressed in 1976 dollars) would be expected with energy sales 65,000 MWH of electricity at 17.5 mils and the steam equivalent of 700,000 MCF of natural gas at $1.80/MCF.

Increases in revenue, whether through higher market prices or increased sales of energy, would improve the rate of return and put it in the 8% to 10% range.

Of particular value would be a reduction in peak energy demands and an increase in total energy demand.

A rough analysis of the impact of inflation on cash flow and rates of return indicates that the viability of the project clearly improves when inflation is taken into account. The capital costs of the facility have been estimated to be in the order of $15.2 million (1976) dollars. As this requires a substantial financial investment it is important to obtain commitments from the suppliers, as well as Ontario Hydro, before proceeding any further with the project. The next section recommends a plan of action for implementation of the project.

7. RECOMMENDED PLAN OF ACTION

The objective of this study has been to prove the technical and economic viability of establishing an energy conversion facility in Hearst, using the wastes available in the area, and to establish the optimum technical approach and funding method under which the plant could operate on a financially sound basis.

It remains to prepare the detailed financial analyses that would be required by funding agencies. This can only be done when the degree of participation by various participants, and the level of funding required, have been established.

This in turn depends upon the grants that could be obtained under various programs. Discussions with Federal and Provincial Agencies having appropriate programs will determine the possibility of obtaining grants. It will then be necessary to prepare the appropriate application dossiers, which might include more detailed analysis of certain costs and benefits. Negotiations with Ontario Hydro will be necessary and contracts to supply wood waste will have to be negotiated with the industries. Since this implies finalizing the basis of payment for waste, possibly by product type, certain operating experience would be desirable prior to long term commitments being made by the Plant. Those agreements in principle should be signed with minimum price and waste guaranteed, but allowing for negotiations and adjustment. Commitments are also required from the users of the steam. In addition the potential clients for steam and their energy requirements will have to be confirmed.

Certain technical features should also be refined. The site location will have to be confirmed, and the soil conditions established, and the site obtained.

The present system design provided for the steam distribution lines to be substantially above ground. Should underground lines be considered more desirable, the effect on the economics will have to be determined.

A proposed plan of action is itemized below:

1. Obtain commitments from participants, including waste suppliers, Ontario Hydro, Hearst P.U.C., energy users and the Hearst Lumbermen's Association.

2. Establish a steering committee authorized to make and execute decisions.

3. Negotiate funding with appropriate government agencies

4. Establish and incorporate organization.

5. Confirm design criteria for the facility.

6. Sign agreements with the participants.

7. Carry out additional technical and economic investigations required (eg. soil conditions etc)

8. Confirm site location and obtain site.

9. Place contracts for engineering and construction of the facilities (including steam distribution system and energy conversion facilities at user locations)

10. Takeover constructed facility.

11. Operate and manage facility.

8. ACKNOWLEDGEMENTS

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TABLE 3.5
ECONOMIC ANALYSIS
PROVINCIAL LEVEL
STEAM AND ELECTRICITY OPTION

3.5 a) Cash Flow
Costs Low
No Disposal Charge

HEARST ENERGY STUDY: B-P TURBINE AT 60000MWH.

YEAR		1978	1979	1980	1981	1982-1999
Capital Outlays	AMOUNT					
Equip & Inst	11500.0					
-----Internal Funds		11500.0	0.0	0.0	0.0	0.0
Building etc.	3700.0					
-----Internal Funds		3700.0	0.0	0.0	0.0	0.0
TOTALS		15200.0	0.0	0.0	0.0	0.0
Annual Expenses						
Waste Purch. (NIL)		0.0	0.0	1.0	1.0	1.0
Transp: Hearst $1.50		0.0	0.0	161.2	161.2	161.2
Transp.Dist $3.00		0.0	0.0	82.5	82.5	82.5
Ash Dispos. $8.50		0.0	0.0	35.0	35.0	35.0
O+M: Parts		0.0	0.0	150.0	150.0	150.0
O+M: Labour		0.0	0.0	250.0	250.0	250.0
O+M: Aux. Gas		0.0	0.0	50.0	50.0	50.0
O+M: Elect.		0.0	0.0	45.0	45.0	45.0
Hydro Standby: Fixed		0.0	0.0	135.0	135.0	135.0
Hydro Standby: Usage		0.0	0.0	30.0	30.0	30.0
TOTALS		0.0	0.0	939.7	939.7	939.7
Annual Revenues						
Steam Sales $1.80		0.0	0.0	1260.0	1260.0	1260.0
Elect. Sales $17.55		0.0	0.0	975.0	975.0	975.0
Dispos. Chrg		0.0	0.0	1.0	1.0	1.0
TOTALS		0.0	0.0	2236.0	2236.0	2236.0
Net Income		0.0	0.0	1296.2	1296.2	1296.2
Cash Flow		-15200.0	0.0	1296.2	1296.2	1296.2

3.5 a) Cash Flow

Costs Low
No Disposal Charge

Continued

Present worth at 2 % =	5470.734
Present worth at 4 % =	1672.145
Present worth at 6 % =	-1107.103
Present worth at 8 % =	-3162.828
Present worth at 10 % =	-4697.672
Present worth at 12 % =	-5852.723
Present worth at 14 % =	-6727.191
Present worth at 16 % =	-7392.000
Present worth at 18 % =	-7898.176
Present worth at 20 % =	-8283.148

3.5 b) Sensitivity Analysis
With Disposal Charge

SENSITIVITY ANALYSIS TEST 1

Items	Sensitivity Coefficient
Equip + Inst	1.00
Building Etc.	1.00
Waste Purch. (NIL)	1.00
Transp: Hearst $1.50	1.00
Transp. Dist $3.00	1.00
Ash Dispos. $8.50	1.00
O+M: Parts	1.00
O+M: Labour	1.00
O+M: Aux. Gas	1.00
O+M: Elect.	1.00
Hydro Standby: Fixed	1.00
Hydro Standby: Usage	1.00
Steam Sales $1.80	1.00
Elect. Sales $17.55	1.00
Dispos. Chrg.	220.00

Internal rate of return (percent) before taxes: 6.85
after taxes: 6.85

TABLE 4.4
ECONOMIC ANALYSIS
HEARST LEVEL
STEAM AND ELECTRICITY OPTION

4.4 a) Cash Flow
Costs Low
No Disposal Charge

HEARST ENERGY STUDY: B-P TURBINE AT 60000MWH.

YEAR		1978	1979	1980	1981	1982-1999
Capital Outlays	AMOUNT					
Equip + Inst	11500.0					
-----Internal Funds		11500.0	0.0	0.0	0.0	0.0
Building Etc.	3700.0					
-----Internal Funds		3700.0	0.0	0.0	0.0	0.0
TOTALS		15200.0	0.0	0.0	0.0	0.0
Annual Expenses						
Waste Purch. (NIL)		0.0	0.0	1.0	1.0	1.0
Transp: Hearst $1.50		0.0	0.0	161.2	161.2	161.2
Transp. Dist $3.00		0.0	0.0	82.5	82.5	82.5
Ash Dispos. $8.50		0.0	0.0	35.0	35.0	35.0
O+M: Parts		0.0	0.0	150.0	150.0	150.0
O+M: Labour		0.0	0.0	250.0	250.0	250.0
O+M: Aux. Gas		0.0	0.0	50.0	50.0	50.0
O+M: Elect.		0.0	0.0	45.0	45.0	45.0
Hydro Standby: Fixed		0.0	0.0	135.0	135.0	135.0
Hydro Standby: Usage		0.0	0.0	30.0	30.0	30.0
TOTALS		0.0	0.0	939.7	939.7	939.7
Annual Revenues						
Steam Sales $1.80		0.0	0.0	1260.0	1260.0	1260.0
Elect. Sales $17.55		0.0	0.0	1141.0	1141.0	1141.0
Dispos. Chrg		0.0	0.0	1.0	1.0	1.0
TOTALS		0.0	0.0	2402.0	2402.0	2402.0
Net Income		0.0	0.0	1462.2	1462.2	1462.2
Cash Flow		-15200.0	0.0	1462.2	1462.2	1462.2

4.4 a) Cash Flow

Costs Low
No Disposal Charge
Continued

Terminal Worth = 0.0
Internal Rate of Return (percent) before taxes: 6.45
after taxes: 6.45

Present worth at 2 % =	8079.691
Present worth at 4 % =	3757.947
Present worth at 6 % =	587.461
Present worth at 8 % =	-1765.527
Present worth at 10 % =	-3529.682
Present worth at 12 % =	-4864.250
Present worth at 14 % =	-5881.211
Present worth at 16 % =	-6660.578
Present worth at 18 % =	-7260.027
Present worth at 20 % =	-7721.797

4.4 b) Sensitivity Analysis
With Disposal Charge

SENSITIVITY ANALYSIS TEST 1

Items	Sensitivity Coefficient
Equip + Inst	1.00
Building Etc.	1.00
Waste Purch. (NIL)	1.00
Transp: Hearst $1.50	1.00
Transp. Dist $3.00	1.00
Ash Dispos. $8.50	1.00
O+M: Parts	1.00
O+M: Labour	1.00
O+M: Aux. Gas	1.00
O+M: Elect.	1.00
Hydro Standby: Fixed	1.00
Hydro Standby: Usage	1.00
Steam Sales $1.80	1.00
Elect. Sales $17.55	1.00
Dispos. Chrg	220.00

Internal rate of return (percent) before taxes: 8.07
after taxes: 8.07

APPENDIX

EQUIPMENT LIST FOR CENTRAL ENERGY GENERATION FACILITY

1 Main boiler: 275,000 pph 650 psig. 700°F, wood waste and refuse fired. Field erected, with FD fan, ID fan, air heater, soot blowers, firing equipment (with provision for emergency firing of natural gas) drive motors, controls, and instrumentation.

3 Boiler feed pumps: 300 USGPM 1500 ft. head at 280°F, complete with electric motor drives.

1 Deaerator: 300,000 pph 40 psig. spray type with 10 min storage capacity.

3 Condensate pumps: 300 USGPM 200 ft. head at 80°F complete with electric motor drives.

1 Condensate tank: vertical 30,000 USG capacity steel tank 15' dia x 30' high.

1 Condenser (air cooled forced convection) 275,000 lb/hr steam at 50 psig, complete with fans and drives.

1 Feed heater (shell and tube) to heat 275,000 lb/hr of boiler feed water from 280°F to 350°F using steam at 150 psig.

1 Turbo alternator: 12 MW @ 15KV, complete package with cooling and lubrication systems.

1 Feedwater treatment system: demineralization plant for 50 USGPM.

1 Condensate polishing plant to handle 500 USGPM of condensate at 200°F.

2 Chemical feeders each consisting of a 100 gal. SS tank and 6.2 USGPH positive displacement pump (900 psi head) - packaged units.

2 Rotary screw air compressors - packaged units 200 SCFM @ 100 psig.

1 Stack-steel, refractory lined 150 ft. high by 6 ft o.d.

1 Belt conveyor for sawdust (30 T/hr) 24" wide by 250 ft. long conveyor starts at ground elev and climbs to a height of approximately 50 ft.

1 Flight conveyor for bark (80 T/hr) 48" wide by 100 ft. long, with rotating chute to distribute bark at discharge. Conveyor starts at ground level and climbs to a height of approx. 50 ft.

1 Flight conveyor for bark (30 T/hr) 48" wide by 50 ft. long.

1 Pneumatic conveying system to handle 30 T/hr of hogged wood waste, conveying it an overall distance of 100 ft. System comprises blower, air-lock feeder, piping and cyclone separator.

1 Flight conveyor for raw refuse (5 T/hr) 26" wide by 50 ft. long.

1 Bulk flo conveyor for shredded refuse (5 T/hr) 12" wide by 80 ft. long. This conveyor will transfer material to the top of the storage bin at an elevation 50 ft. above grade.

1 Bulk flo conveyor for coarse ash (1 T/hr) 8" wide by 50 ft. long. This conveyor will transfer material from the basement to a tote bin outside the plant.

1 Weigh station capable of handling vehicles with a gross weight of 40 tons, and overall length of 60 ft.

2 Storage bins (one for sawdust, one for hogged bark and shredded refuse). Live bottom storage bins 32 ft. long x 29 ft. high.

1 Bark hog to handle 30 T/hr. complete with drive motor hopper and wood, control panel.

1 Refuse shredder to handle 5 T/hr.

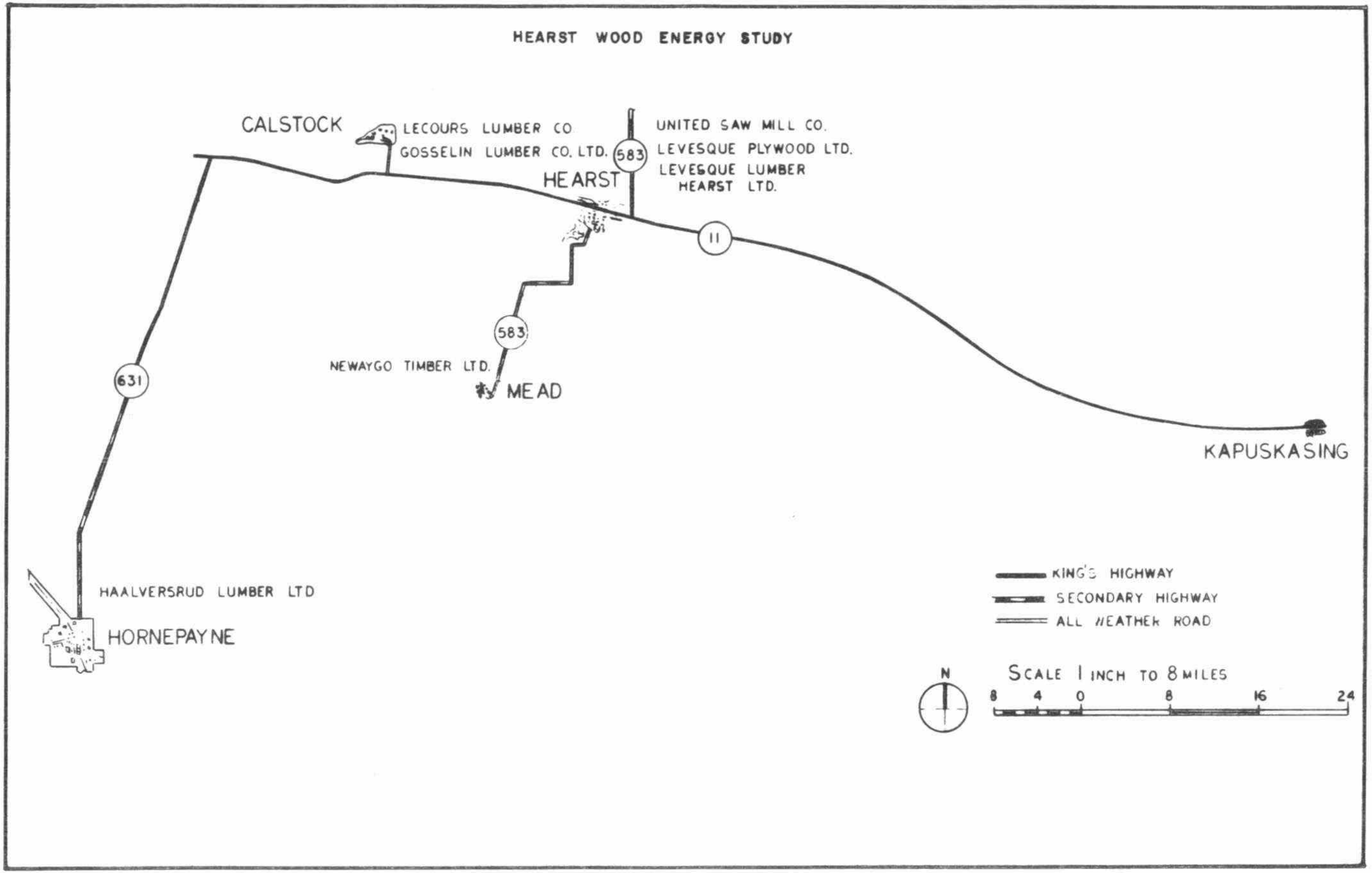


FIGURE 1: LOCATION OF POTENTIAL, WOOD WASTE SOURCES

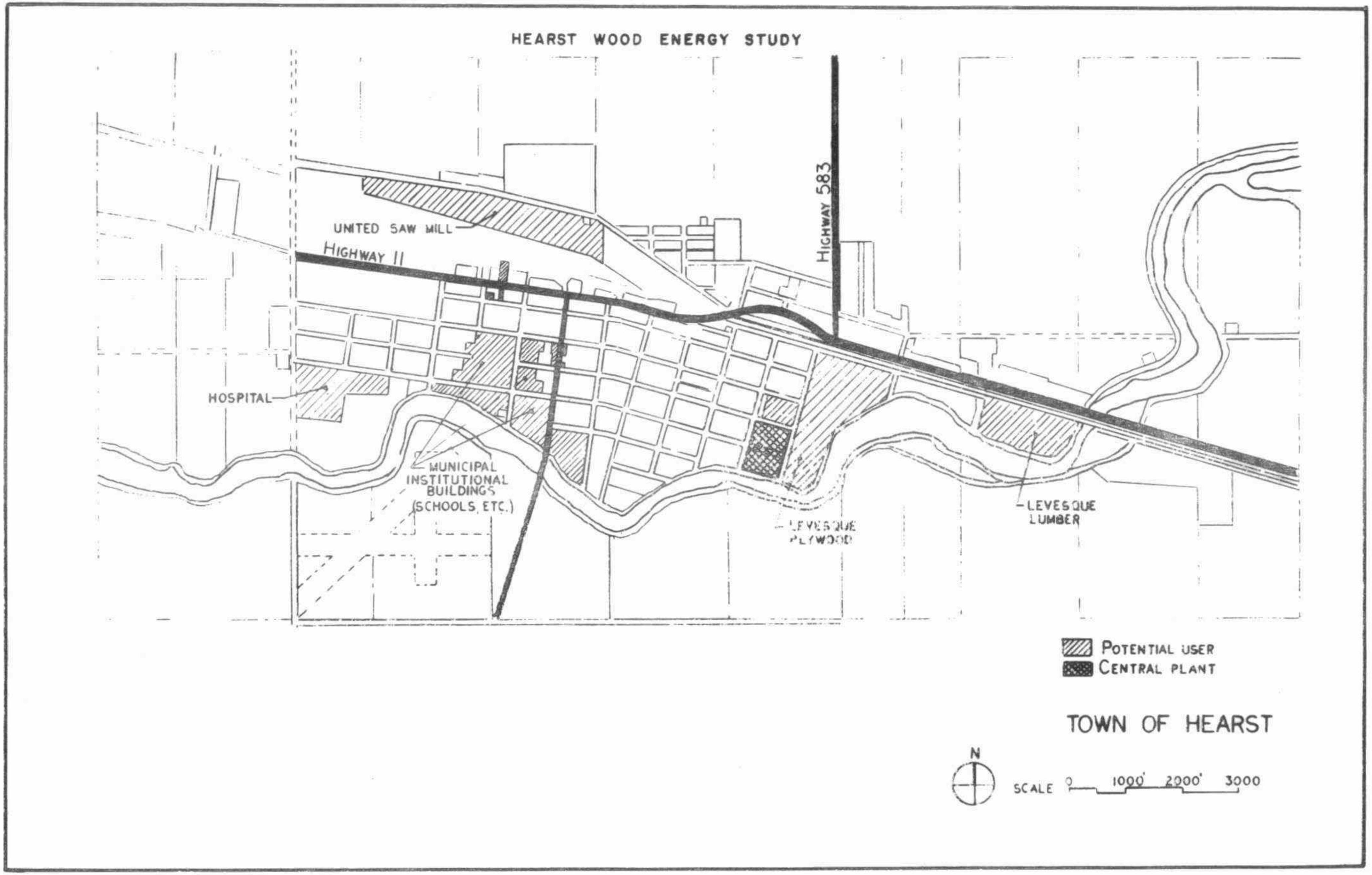
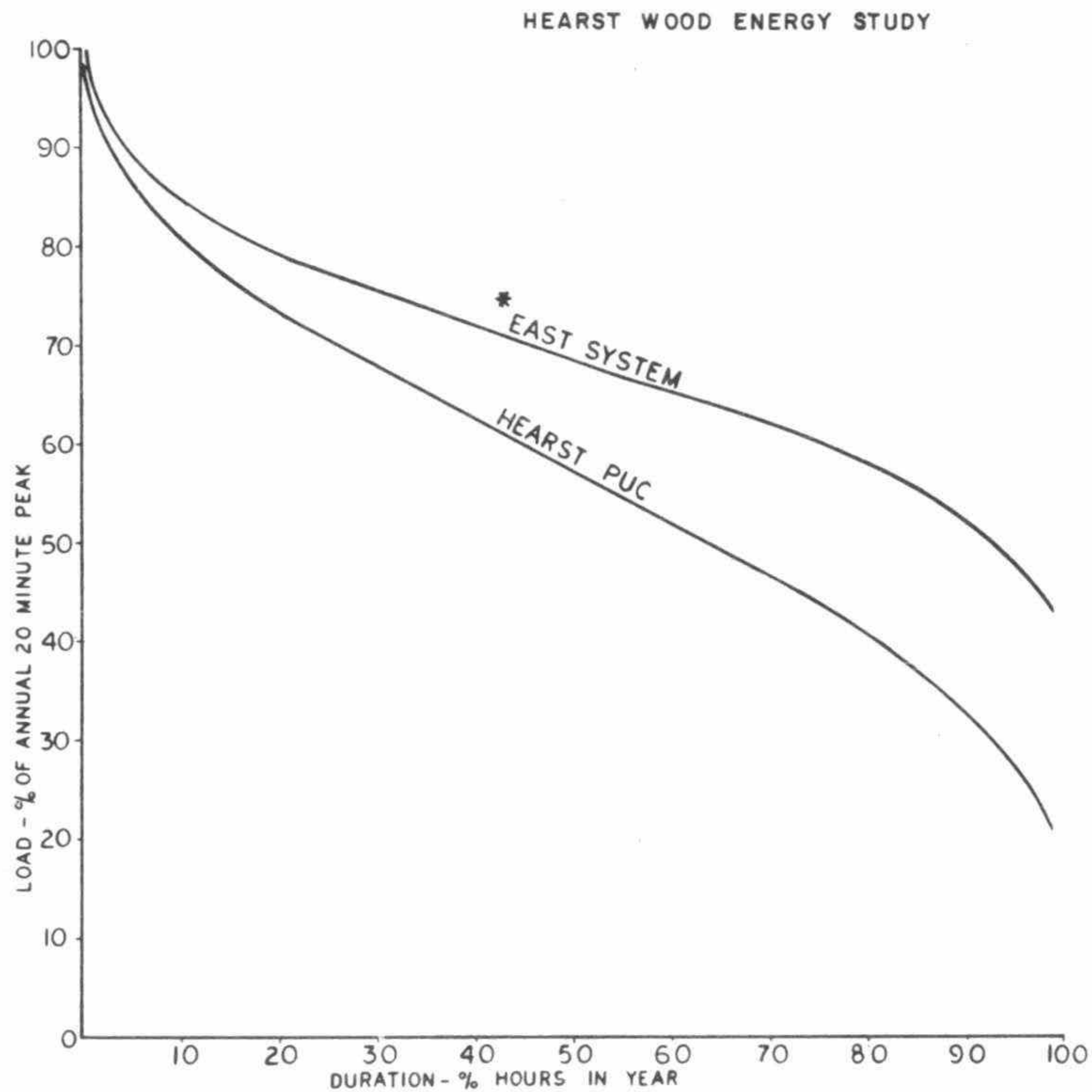


FIGURE 2 : POTENTIAL USERS OF HEAT ENERGY FROM CENTRAL PLANT



NOTE

* THE "EAST" SYSTEM IS AN ELECTRICITY DISTRIBUTION SYSTEM SUGGESTED AS TYPICAL BY ONTARIO HYDRO

FIGURE 3 : *EAST SYSTEM AND HEARST PUC LOAD DURATION CURVES FOR 1974

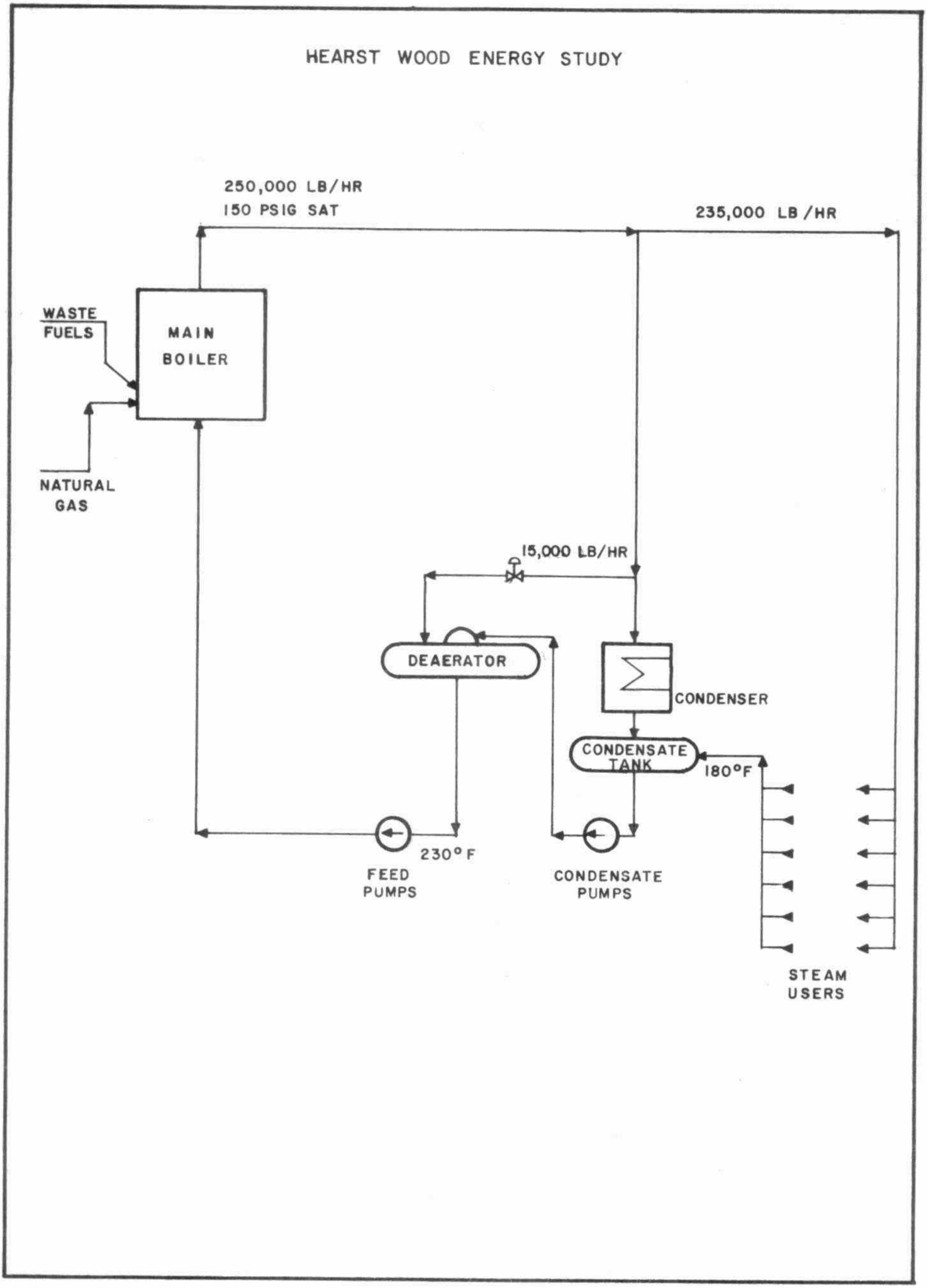


FIGURE 4 : LOW PRESSURE STEAM GENERATION SYSTEM

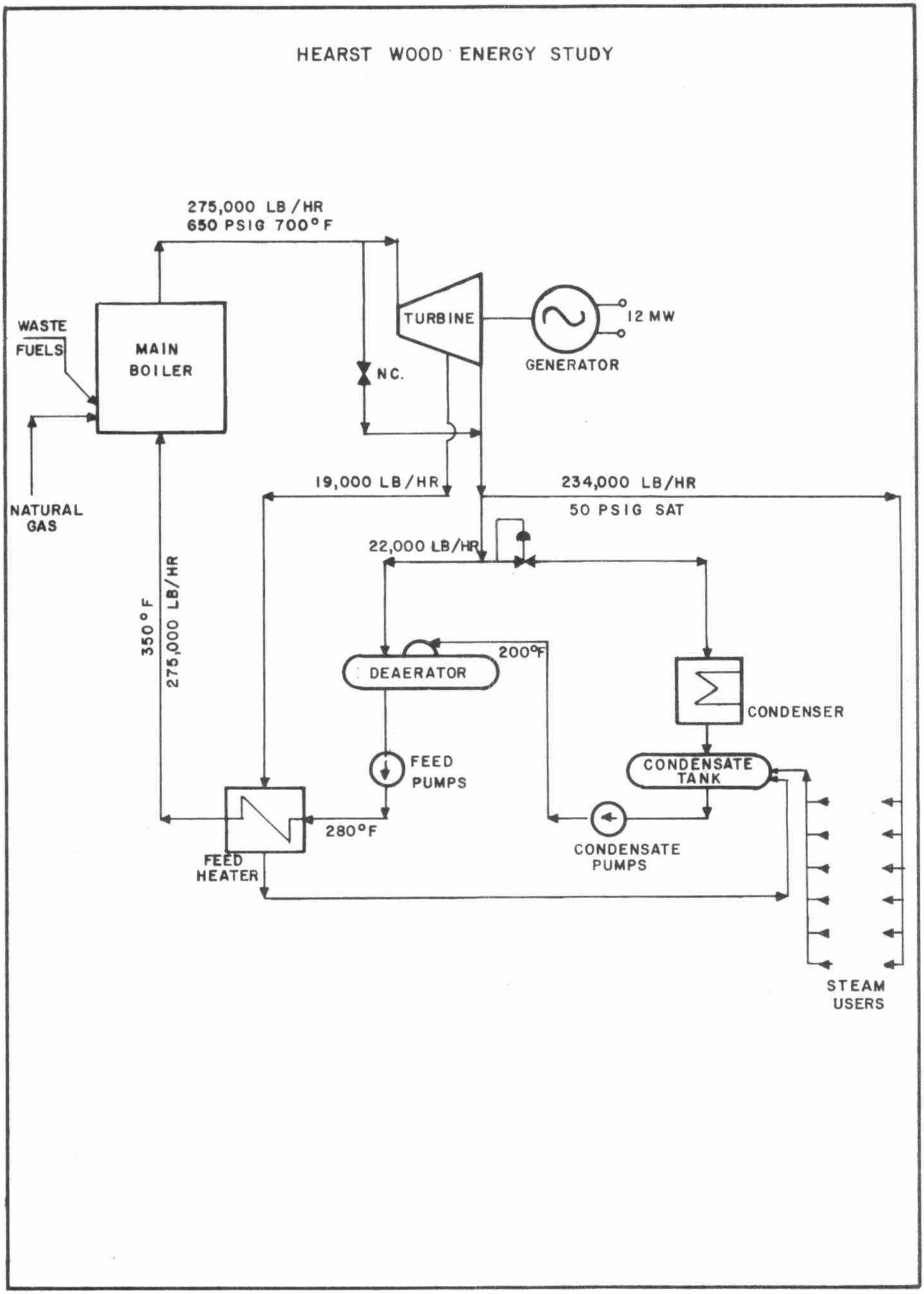


FIGURE 5: MEDIUM PRESSURE STEAM AND ELECTRICITY GENERATION SYSTEM

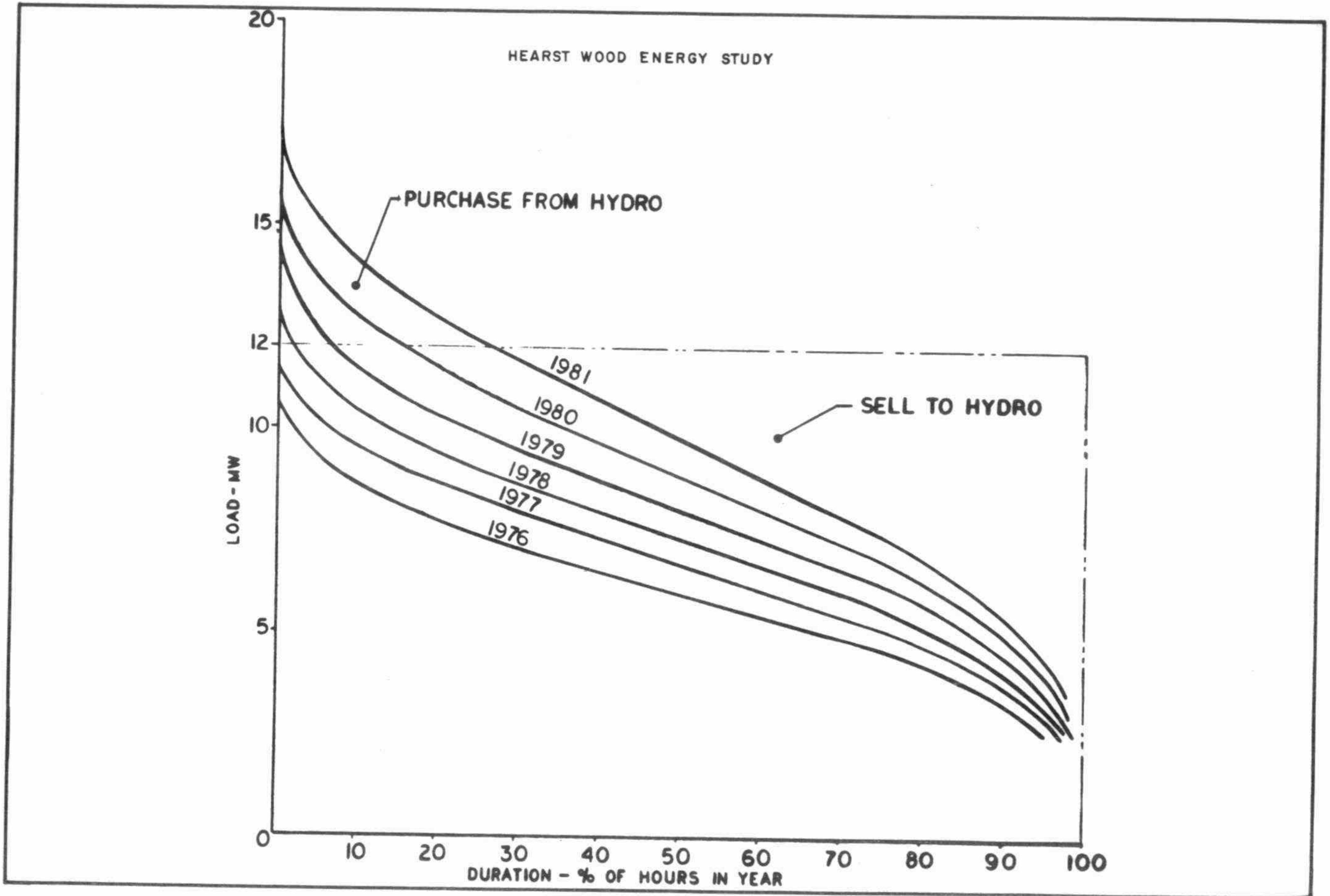


FIGURE 6 : HEARST PUC LOAD DURATION CURVES FOR PERIOD 1976 - 1981 (PROJECTED)

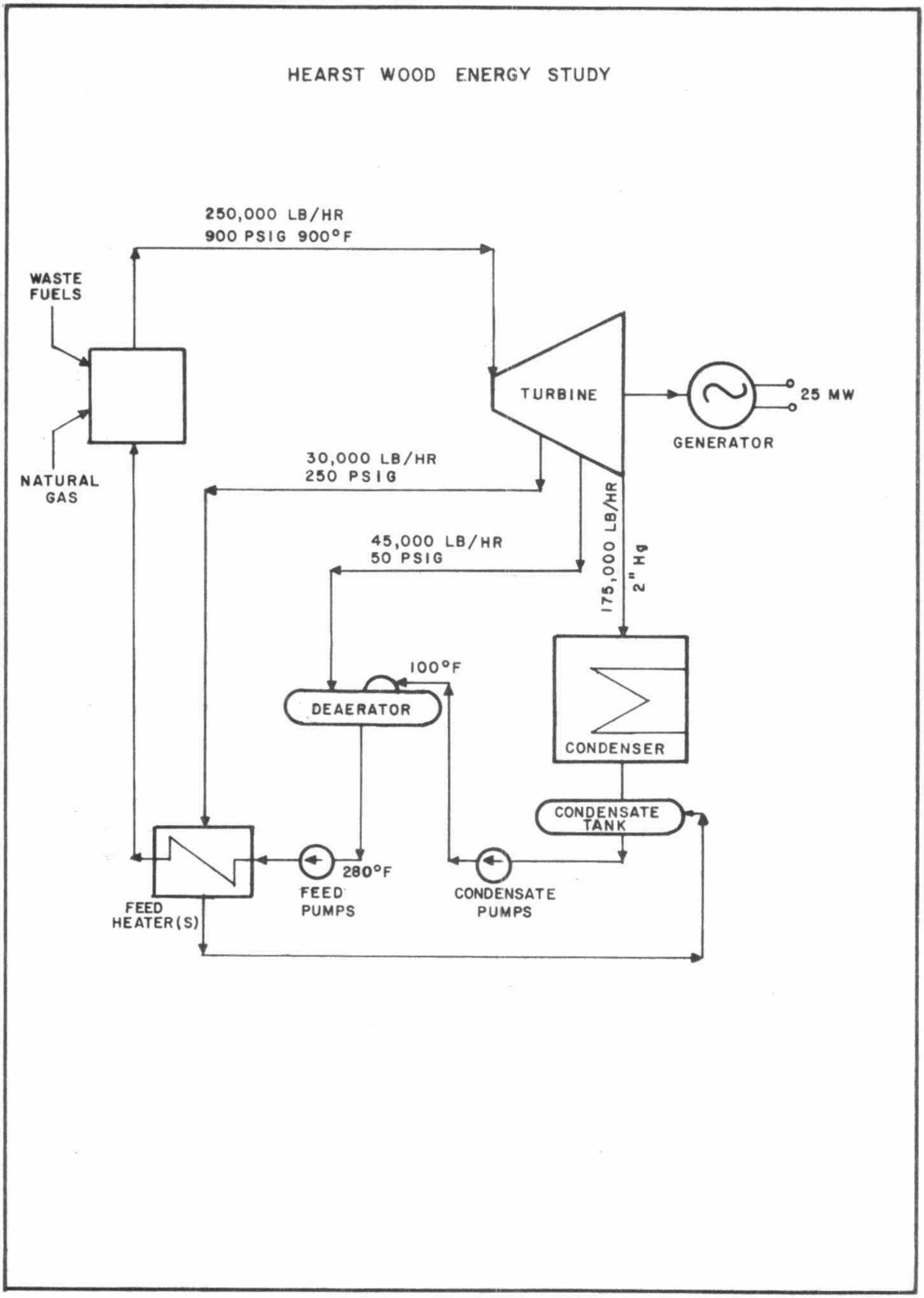


FIGURE 7: ELECTRICITY GENERATION SYSTEM

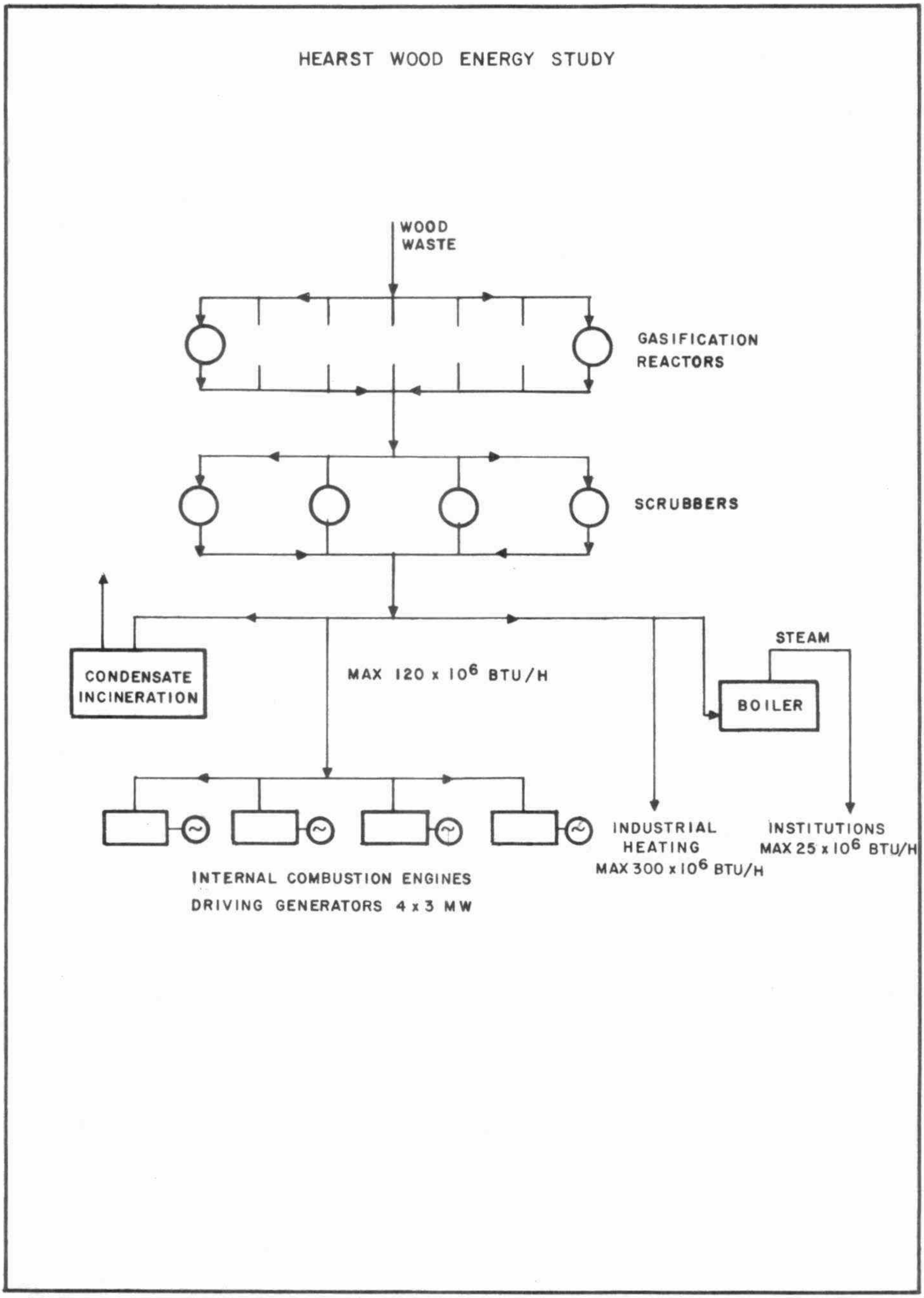


FIGURE 8 : GASIFICATION PROCESS

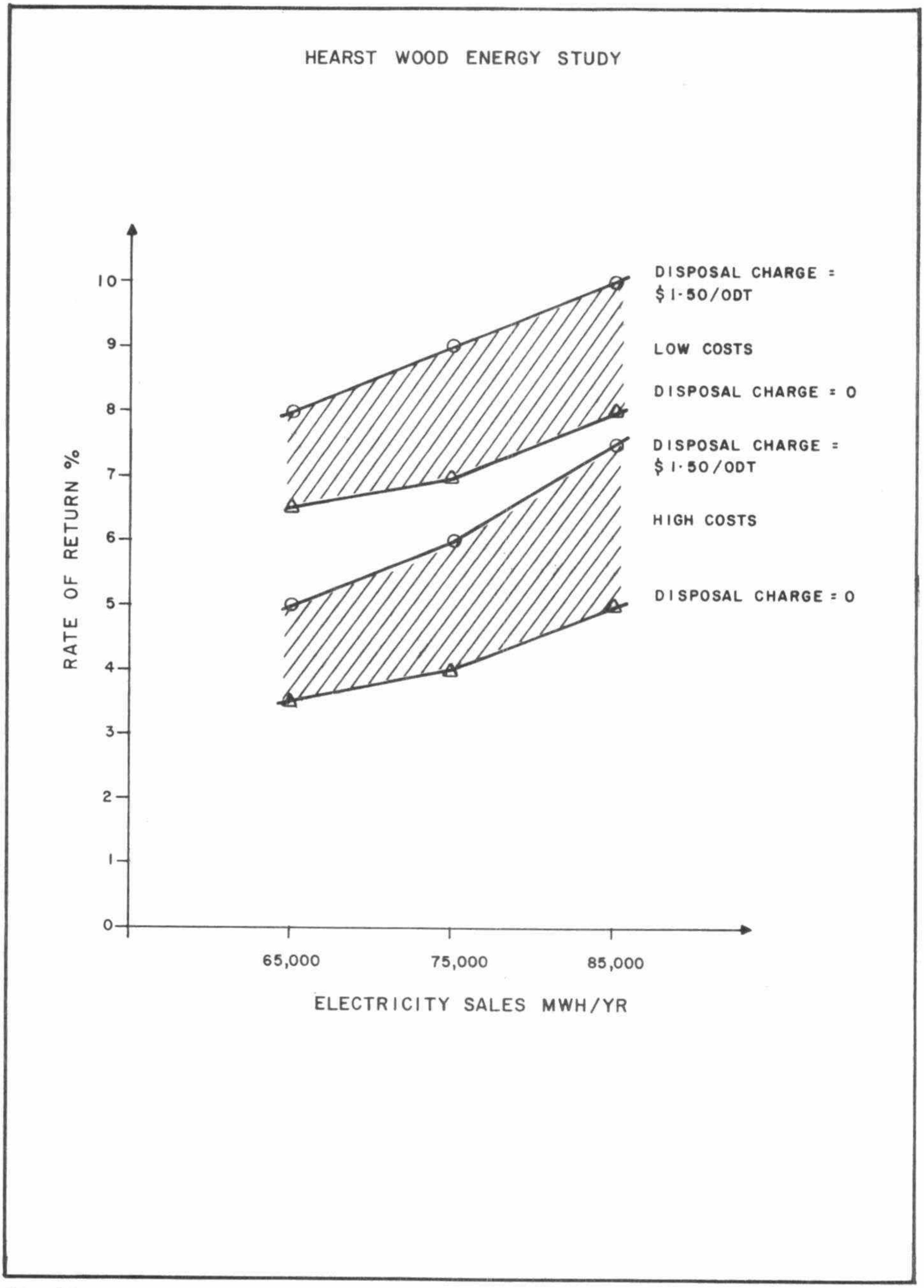


FIGURE 9 : STEAM AND ELECTRICITY OPTION, RATE OF RETURN VS ELECTRICITY SALES

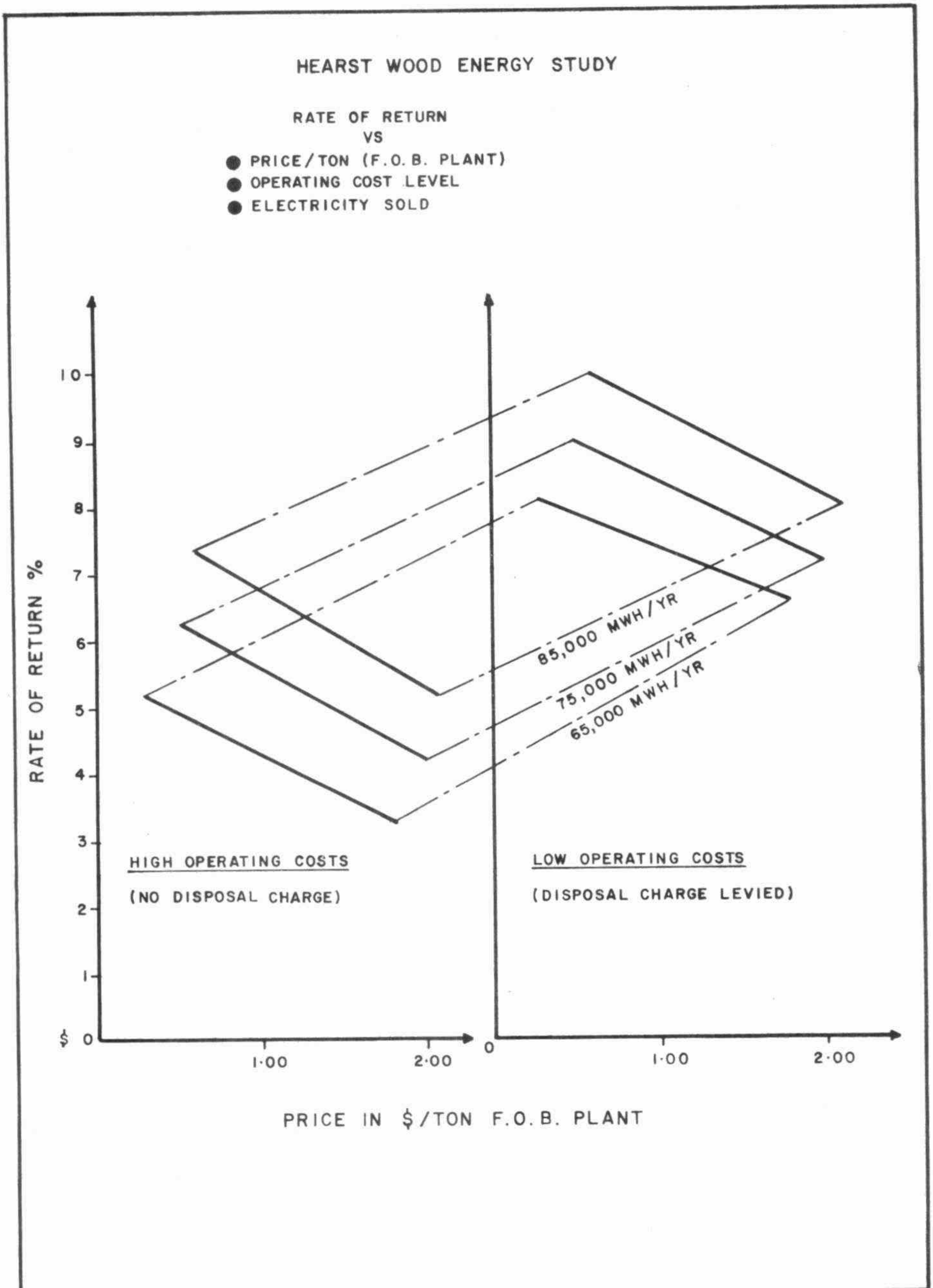


FIGURE 10 : STEAM AND ELECTRICITY OPTION

HEARST WOOD ENERGY STUDY

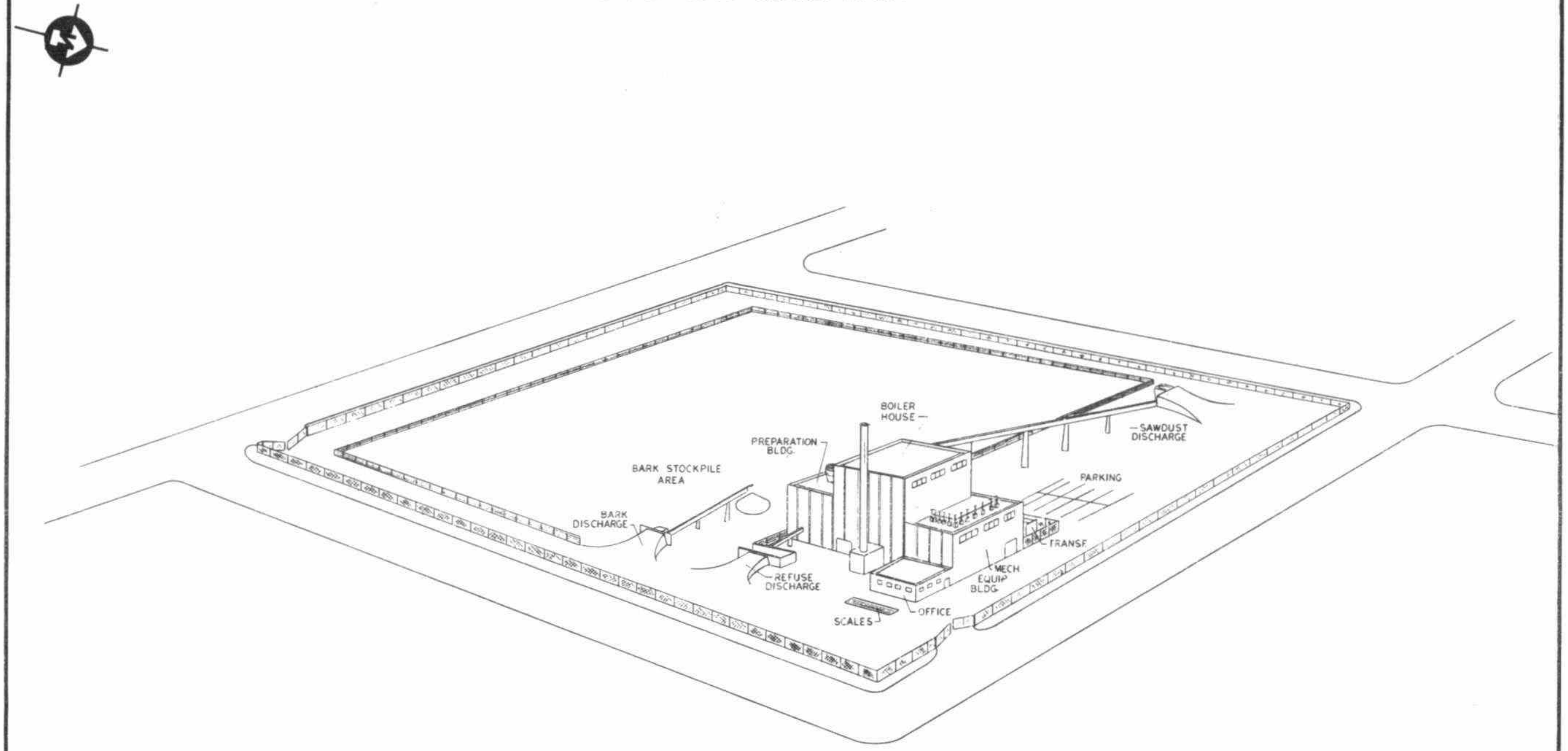


FIGURE 11: ENERGY CONVERSION FACILITY, PERSPECTIVE VIEW OF PLANT

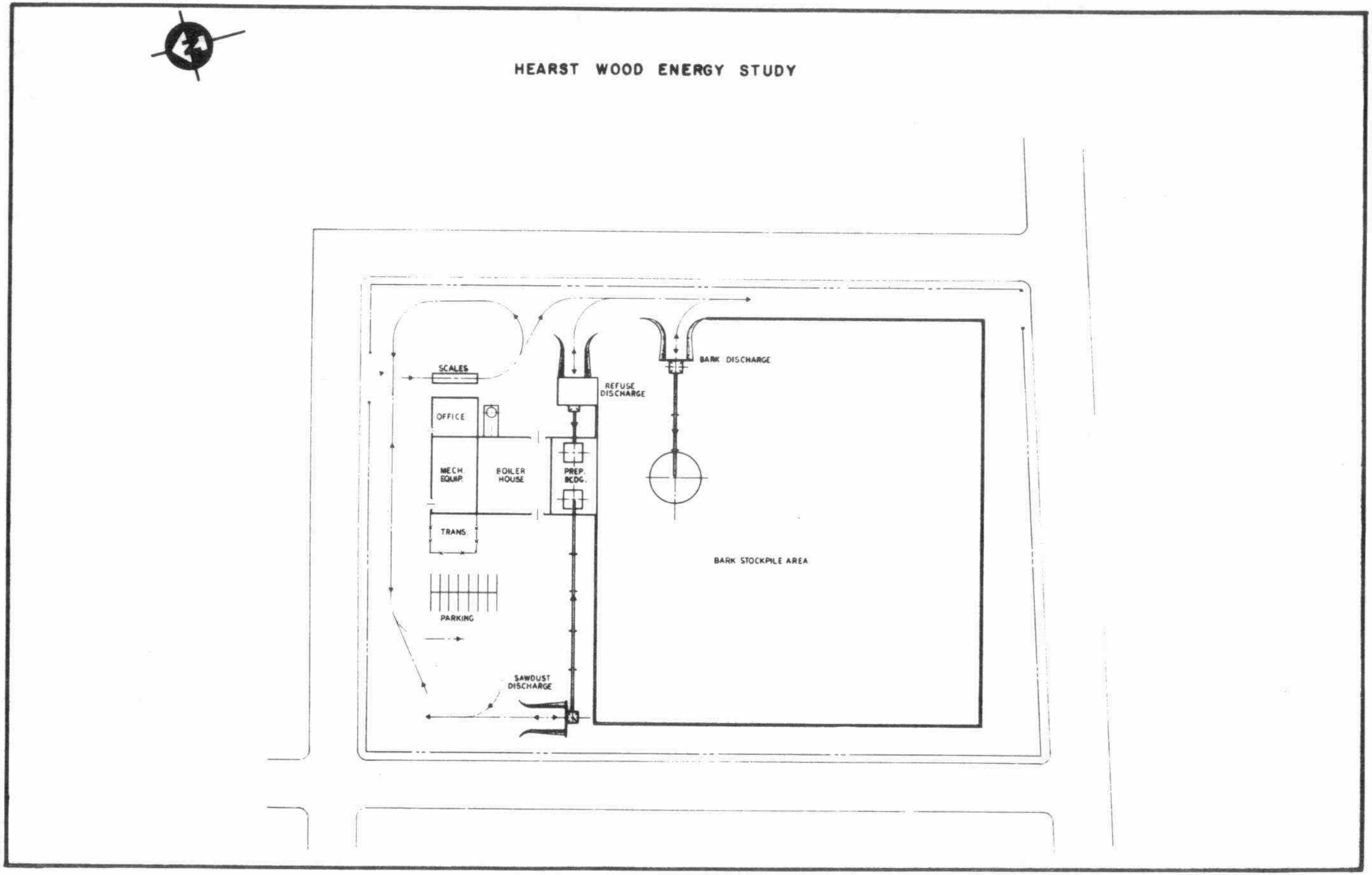


FIGURE 12: ENERGY CONVERSION FACILITY, TENTATIVE SITE PLAN

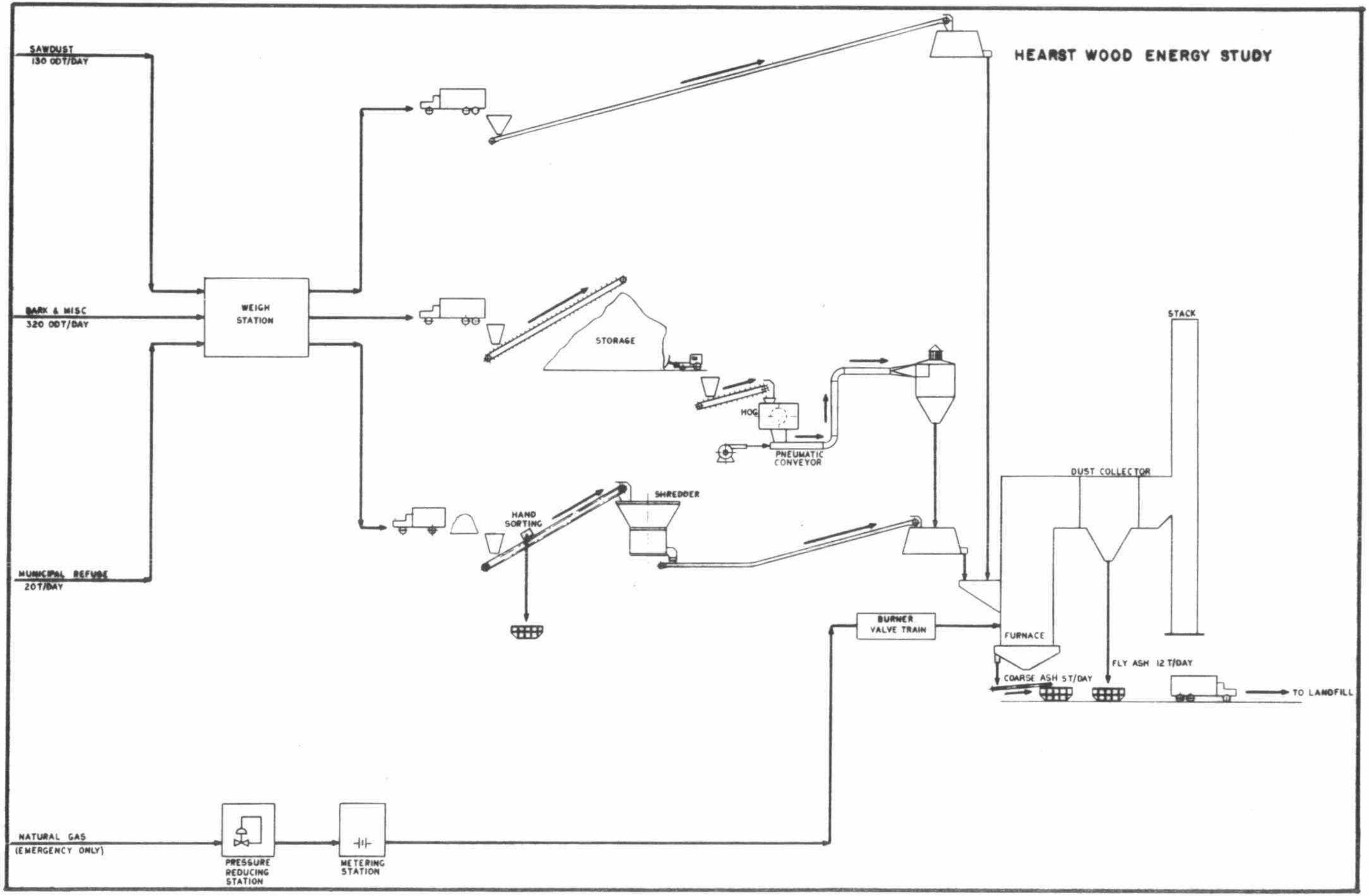


FIGURE 13: ENERGY CONVERSION FACILITY, WOOD WASTE, MUNICIPAL REFUSE, NATURAL GAS AND ASH, FLOW DIAGRAM

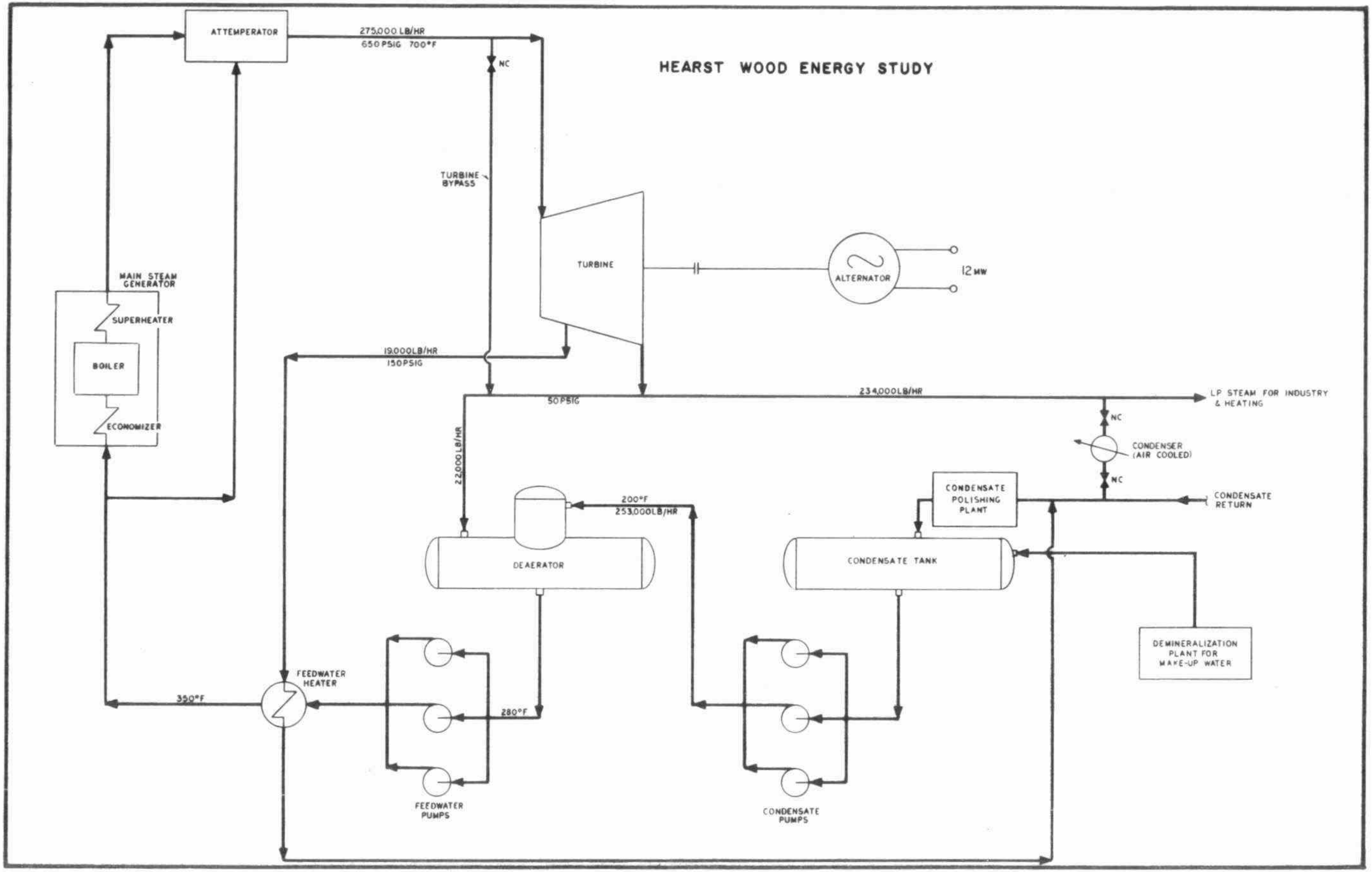


FIGURE 14: ENERGY CONVERSION FACILITY, STEAM, CONDENSATE AND FEEDWATER, FLOW DIAGRAM

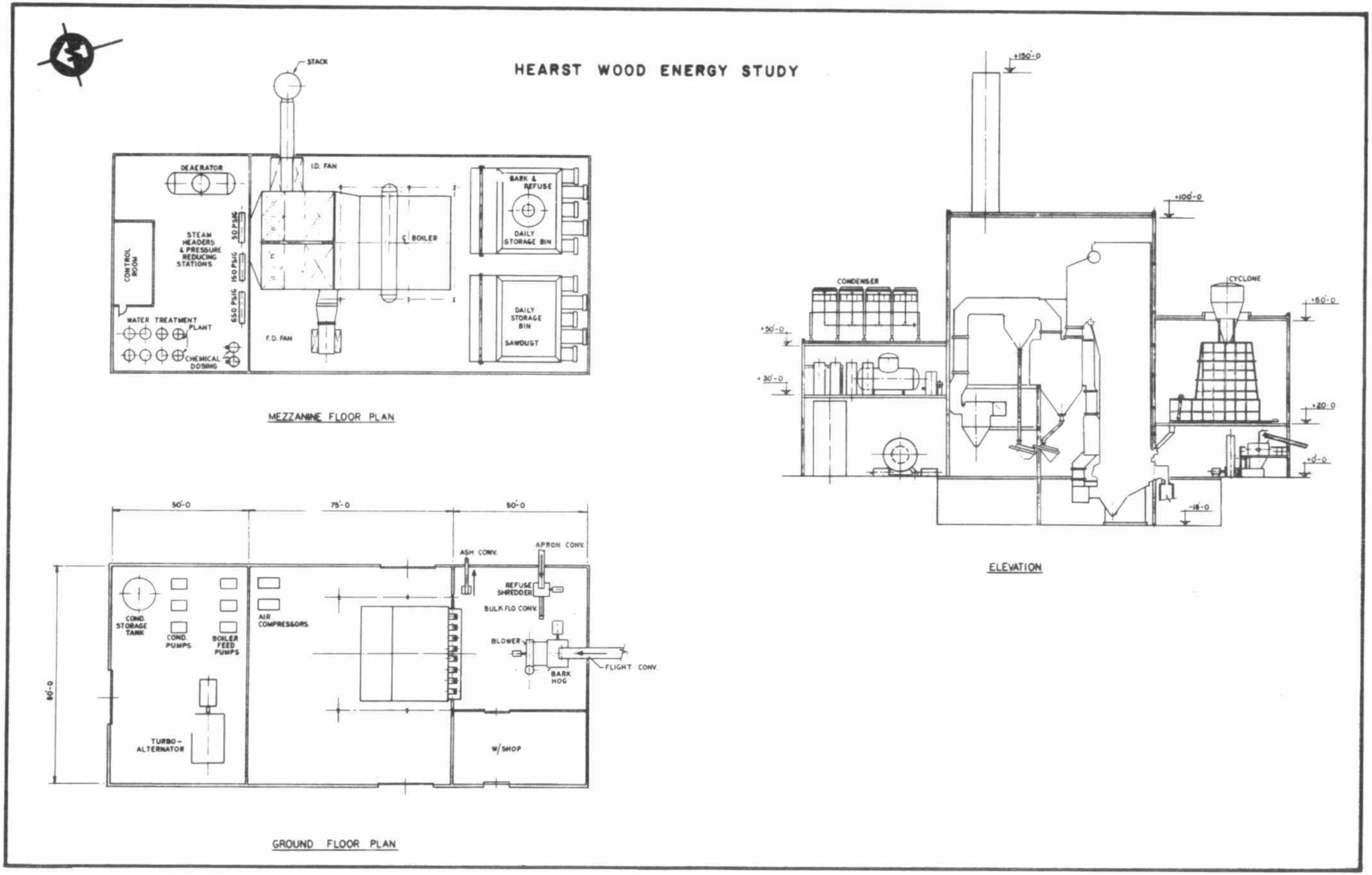


FIGURE 15: ENERGY CONVERSION FACILITY, BOILER AND TURBINE HOUSE, GENERAL ARRANGEMENT